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(54) **METHODS AND MODULES FOR MANAGING PACKETS IN A SOFTWARE DEFINED NETWORK**

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H04L 12/24	(2006.01)
H04L 12/715	(2006.01)

(52) **U.S. Cl.**

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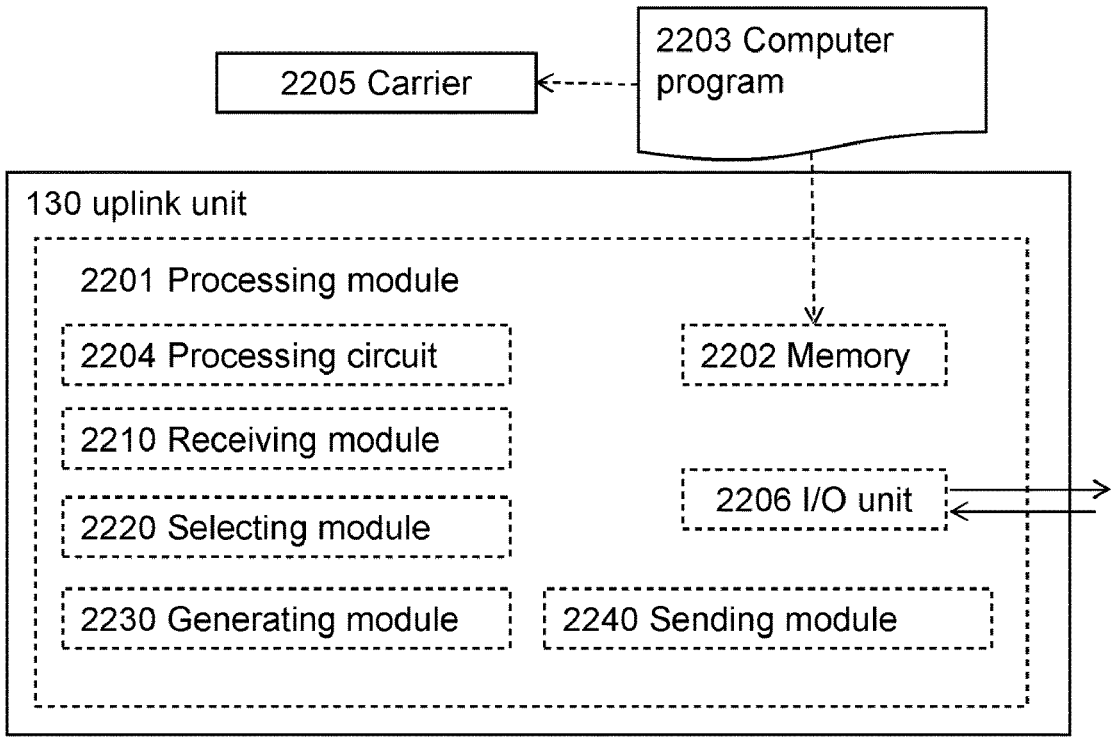
(57) **ABSTRACT**

Methods, an uplink module (**130**), downlink module (**160**), an entry module (**170**) and a management module (**147**) for managing packets in a communication system (**100**) based on Software Defined Networking are disclosed. A data plane of the communication system (**100**) comprises a forwarding module (**140**), a service module (**145**) and the entry module (**170**) and a control plane of the communication system (**100**) comprises the management module (**147**). The entry module (**170**) receives (**8**) an Internet Protocol "IP" packet from the peer device (**180**), wherein the IP packet includes a destination IP address associated with the mobile device (**120**). The entry module (**170**) obtains (**9**), from the management module (**147**), a location value specifying the radio network node (**110**) associated with the destination IP address. The entry module (**170**) associates (**10**) the location value with the IP packet, wherein the location value is related to a location tag name, indicating the radio network node (**110**) that serves the mobile device (**20**), thereby obtaining a packet. The entry module (**170**) sends (**11**) the packet, via the forwarding module (**140**), towards the radio network node (**110**) as indicated by the location value of the location tag name. Corresponding computer programs and carriers therefor are also disclosed.



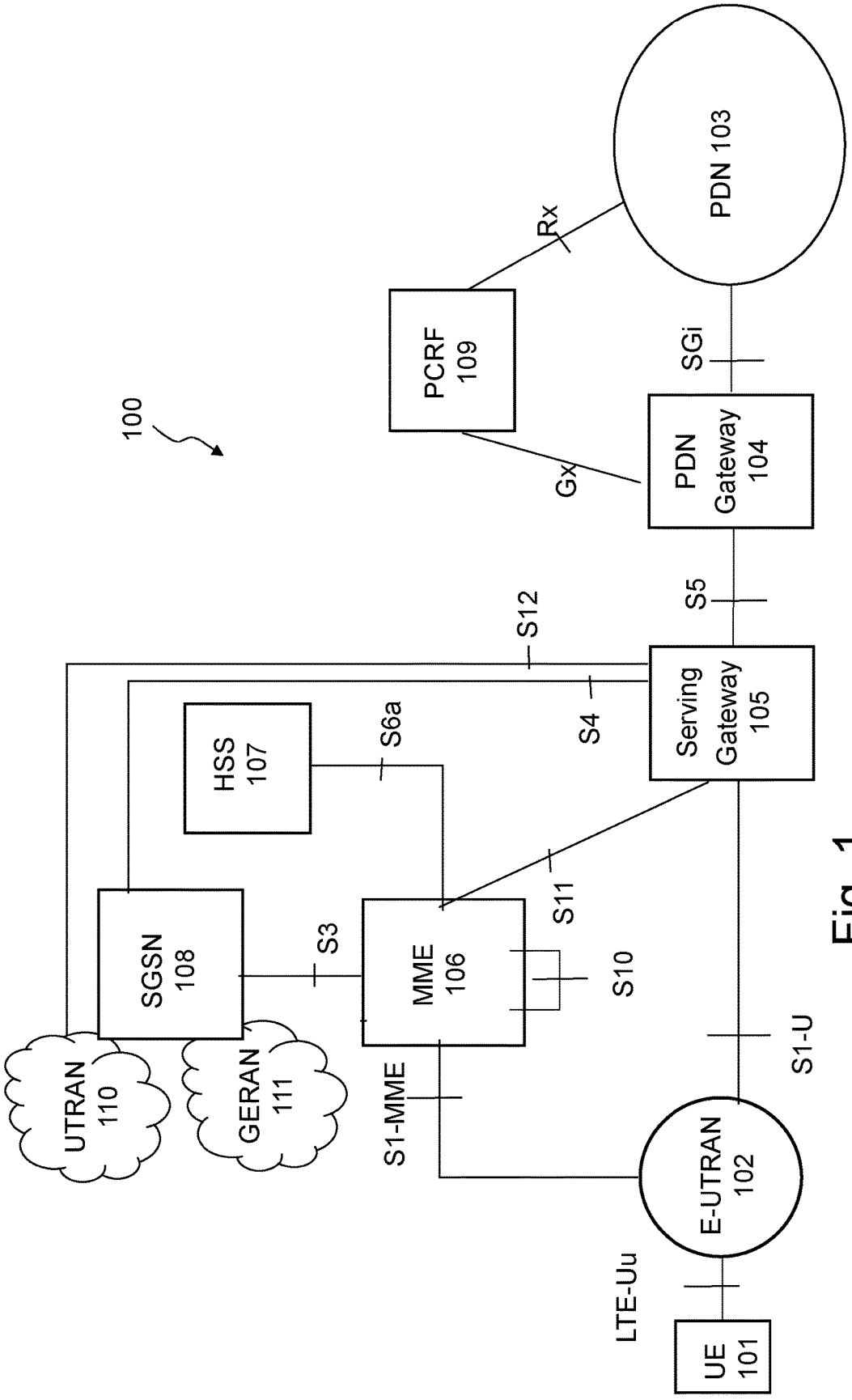

100
PDN 103
Rx
PCRF 109
SGi
PDN Gateway 104
Gx
S5
S12
Serving Gateway 105
S4
HSS 107
S6a
S11
SGSN 108
S3
MME 106
S10
S1-U
UTRAN 110
GERAN 111
S1-MME
E-UTRAN 102
LTE-Uu
UE 101

Fig. 1

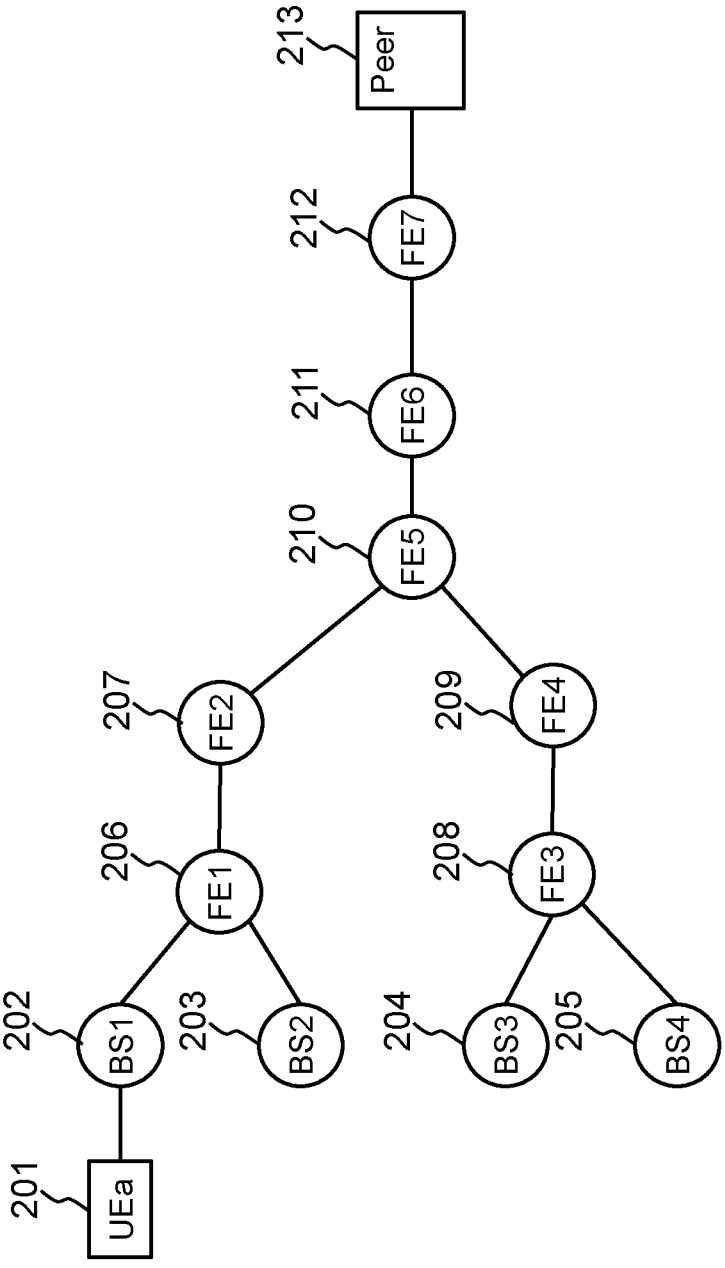

213
Peer
212
FE7
211
FE6
210
FE5
207
FE2
209
FE4
206
FE1
208
FE3
202
BS1
203
BS2
204
BS3
205
BS4
201
UEa

Fig. 2

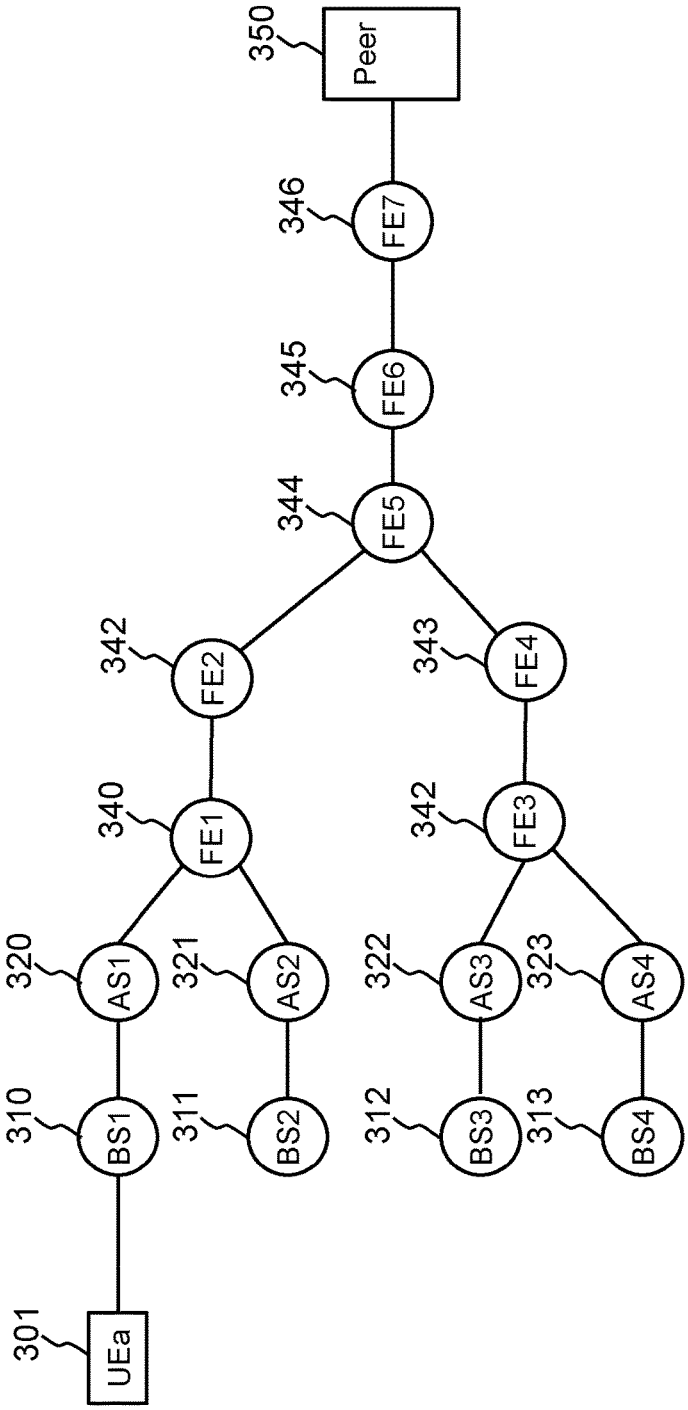

350
Peer
346
FE7
345
FE6
344
FE5
342
FE2
343
FE4
340
FE1
342
FE3
320
AS1
321
AS2
322
AS3
323
AS4
310
BS1
311
BS2
312
BS3
313
BS4
301
UEa

Fig. 3

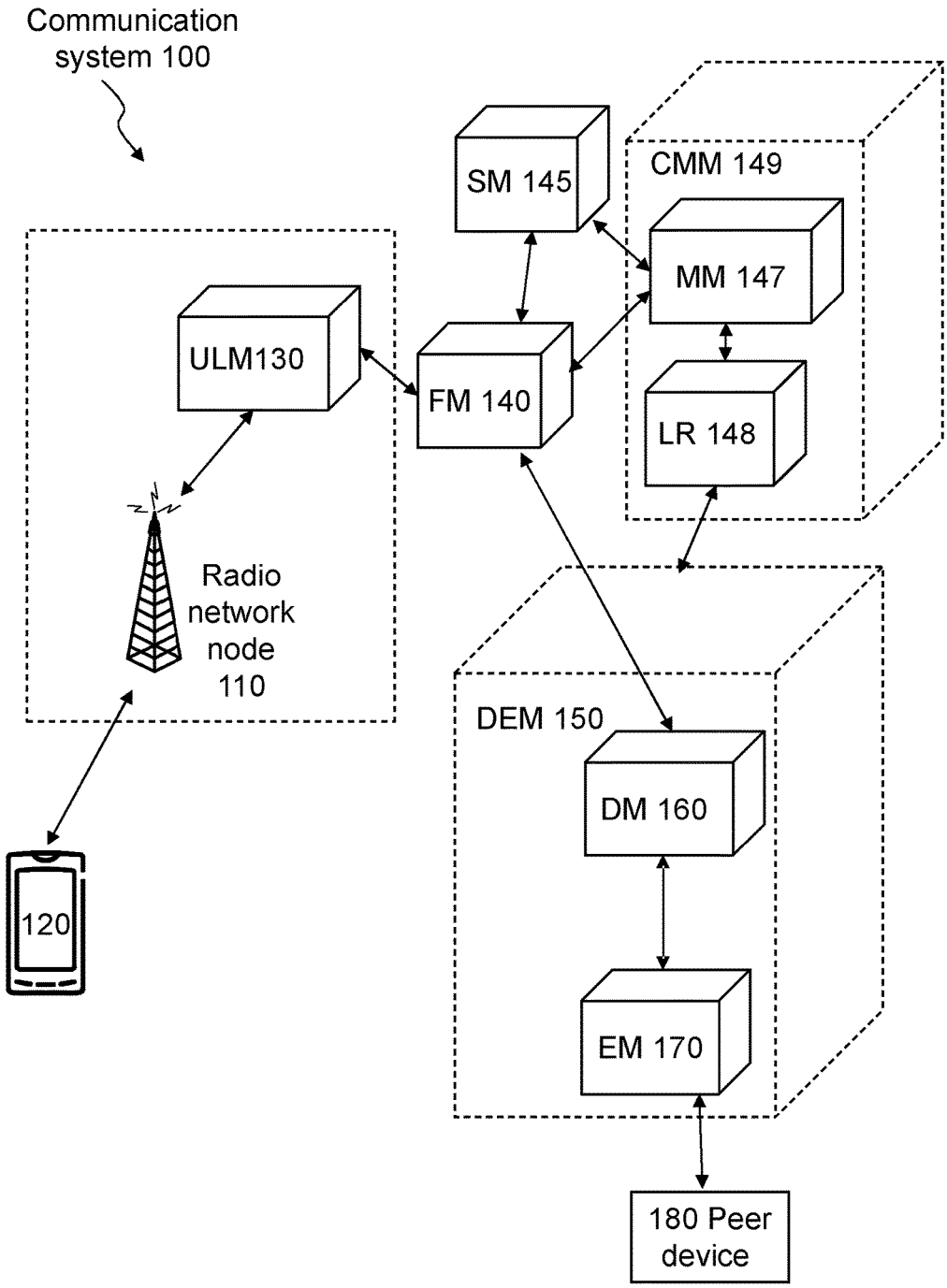
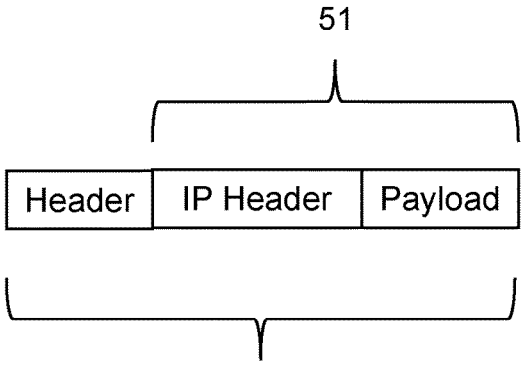

Communication system 100
SM 145
CMM 149
MM 147
ULM130
FM 140
LR 148
Radio network node 110
DEM 150
DM 160
120
EM 170
180 Peer device

Fig. 4



"New" Packet including header that comprises one or more tags and values as described in the application text

Fig. 5

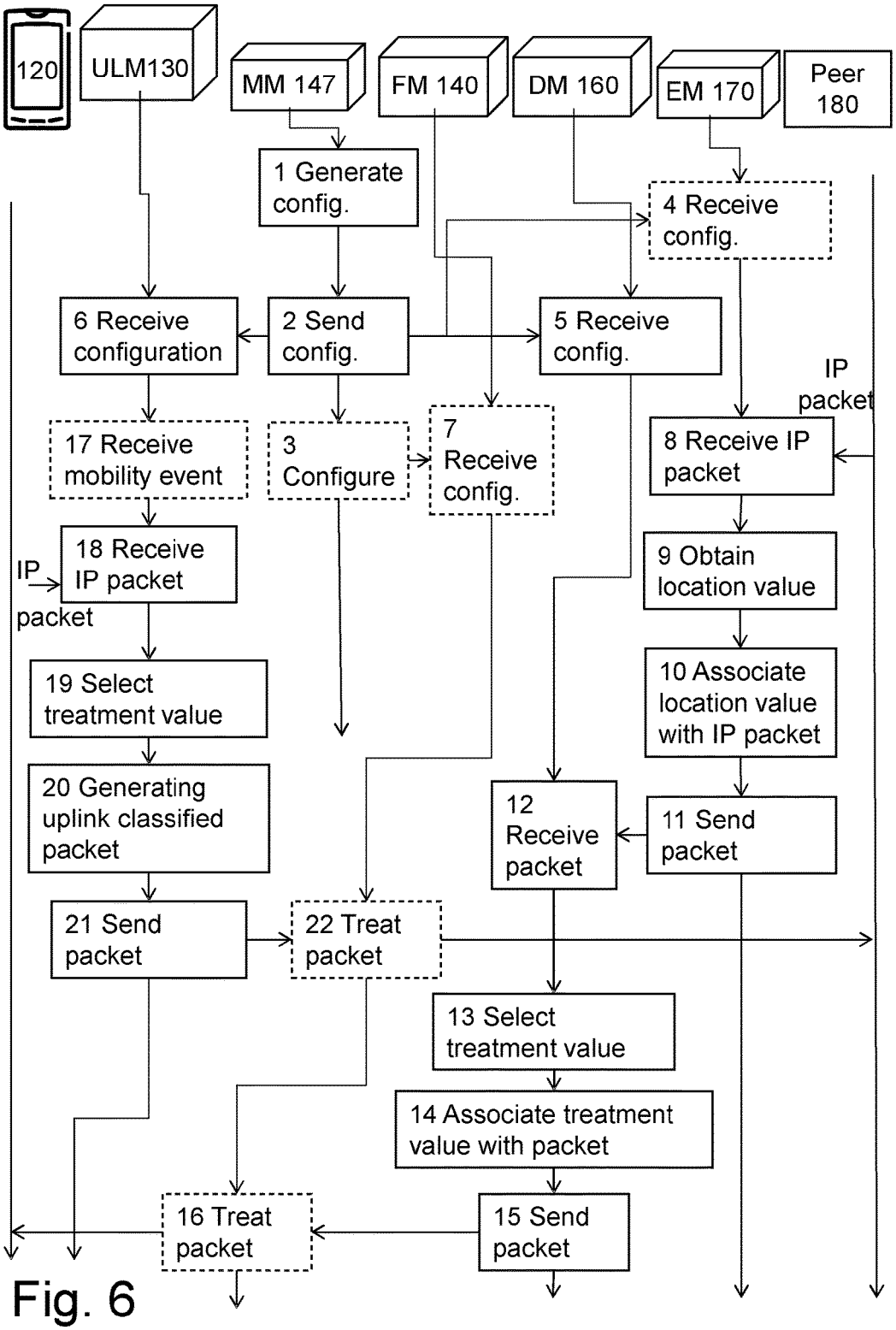
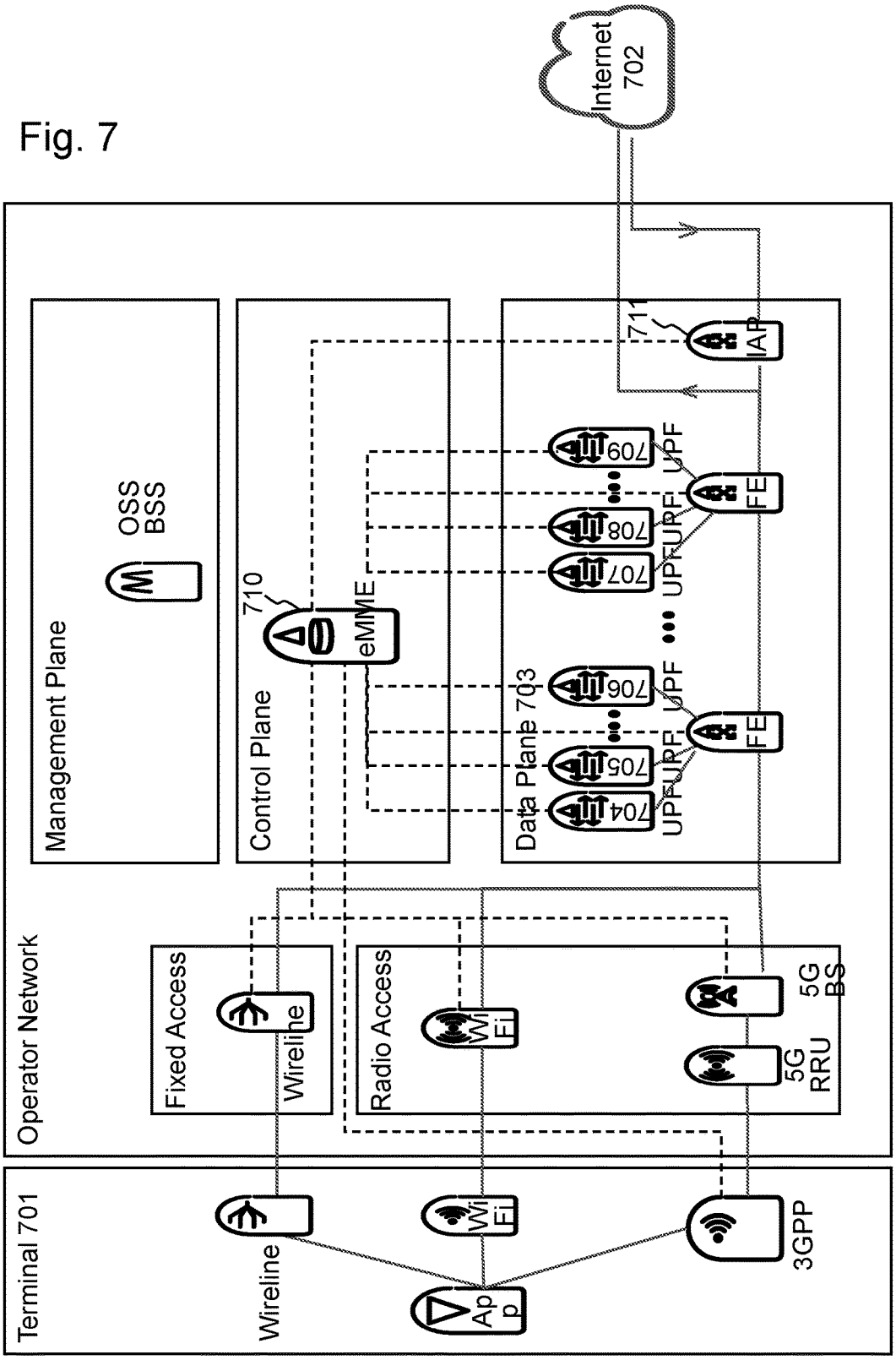

120
ULM130
MM 147
FM 140
DM 160
EM 170
Peer 180
1 Generate config.
4 Receive config.
6 Receive configuration
2 Send config.
5 Receive config.
IP packet
17 Receive mobility event
3 Configure
7 Receive config.
8 Receive IP packet
18 Receive IP packet
IP packet
9 Obtain location value
19 Select treatment value
10 Associate location value with IP packet
20 Generating uplink classified packet
12 Receive packet
11 Send packet
21 Send packet
22 Treat packet
13 Select treatment value
14 Associate treatment value with packet
16 Treat packet
15 Send packet

Fig. 6

Fig. 7


Internet
702
Operator Network
Management Plane
OSS
BSS
M
Control Plane
710
eMME
Data Plane 703
711
IAP
709
708
707
706
705
704
UPF
FE
Fixed Access
Wireline
Radio Access
Wi
Fi
5G
RRU
5G
BS
Terminal 701
Wireline
Wi
Fi
Ap
p
3GPP

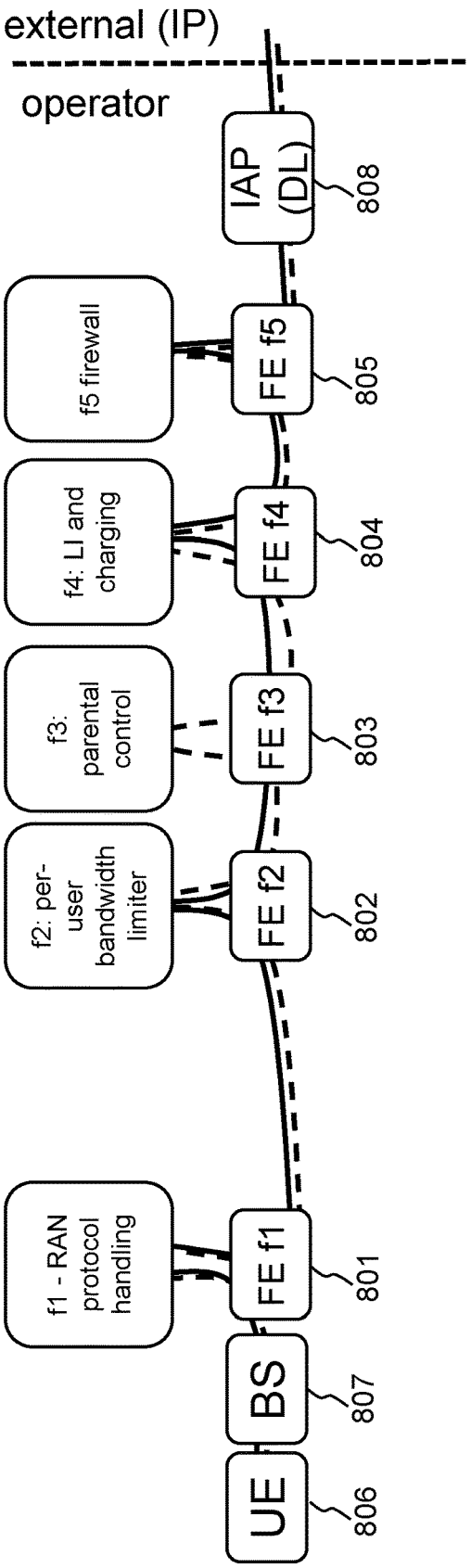

external (IP)
operator
IAP (DL)
808
f5 firewall
FE f5
805
f4: LI and charging
FE f4
804
f3: parental control
FE f3
803
f2: per-user bandwidth limiter
FE f2
802
f1 - RAN protocol handling
FE f1
801
BS
807
UE
806

Fig. 8

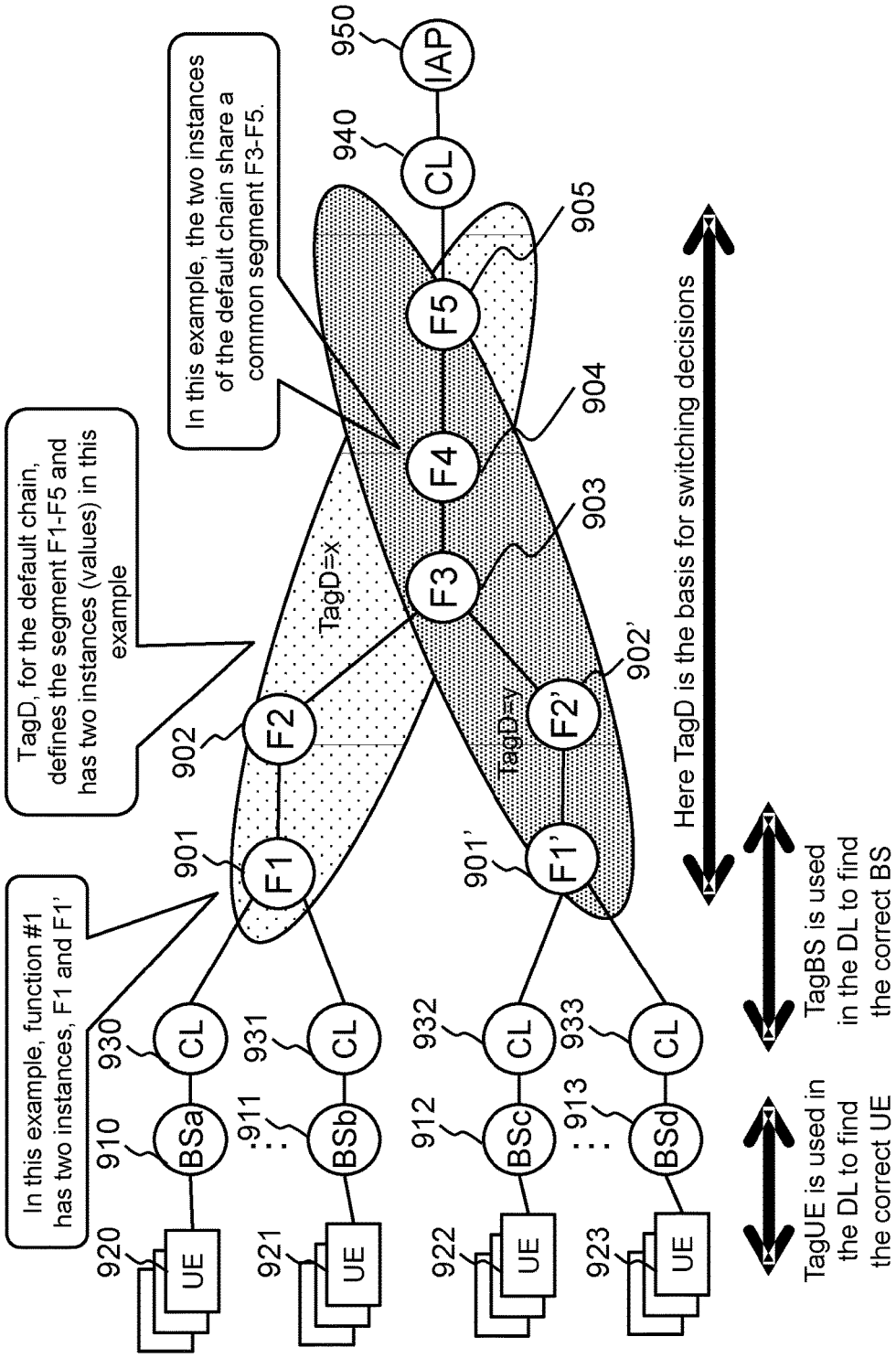

In this example, function #1 has two instances, F1 and F1'
TagD, for the default chain, defines the segment F1-F5 and has two instances (values) in this example
In this example, the two instances of the default chain share a common segment F3-F5.
Here TagD is the basis for switching decisions
TagD=x
TagD=y
F1
F2
F3
F4
F5
F1'
F2'
IAP
CL
BSa
BSb
BSc
BSd
UE
901
902
903
904
905
901'
902'
910
911
912
913
920
921
922
923
930
931
932
933
940
950
TagUE is used in the DL to find the correct UE
TagBS is used in the DL to find the correct BS

Fig. 9

Fig. 10

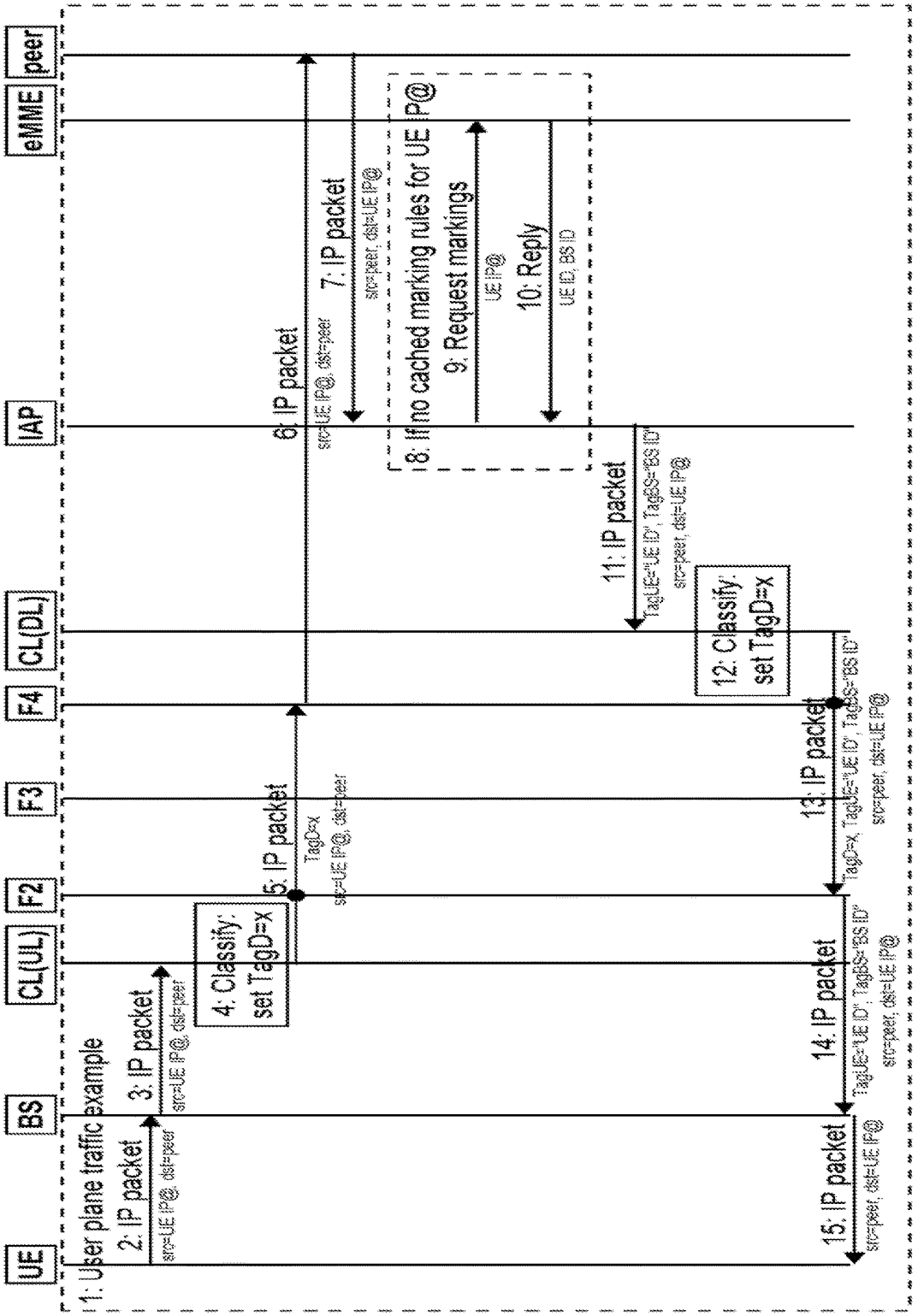
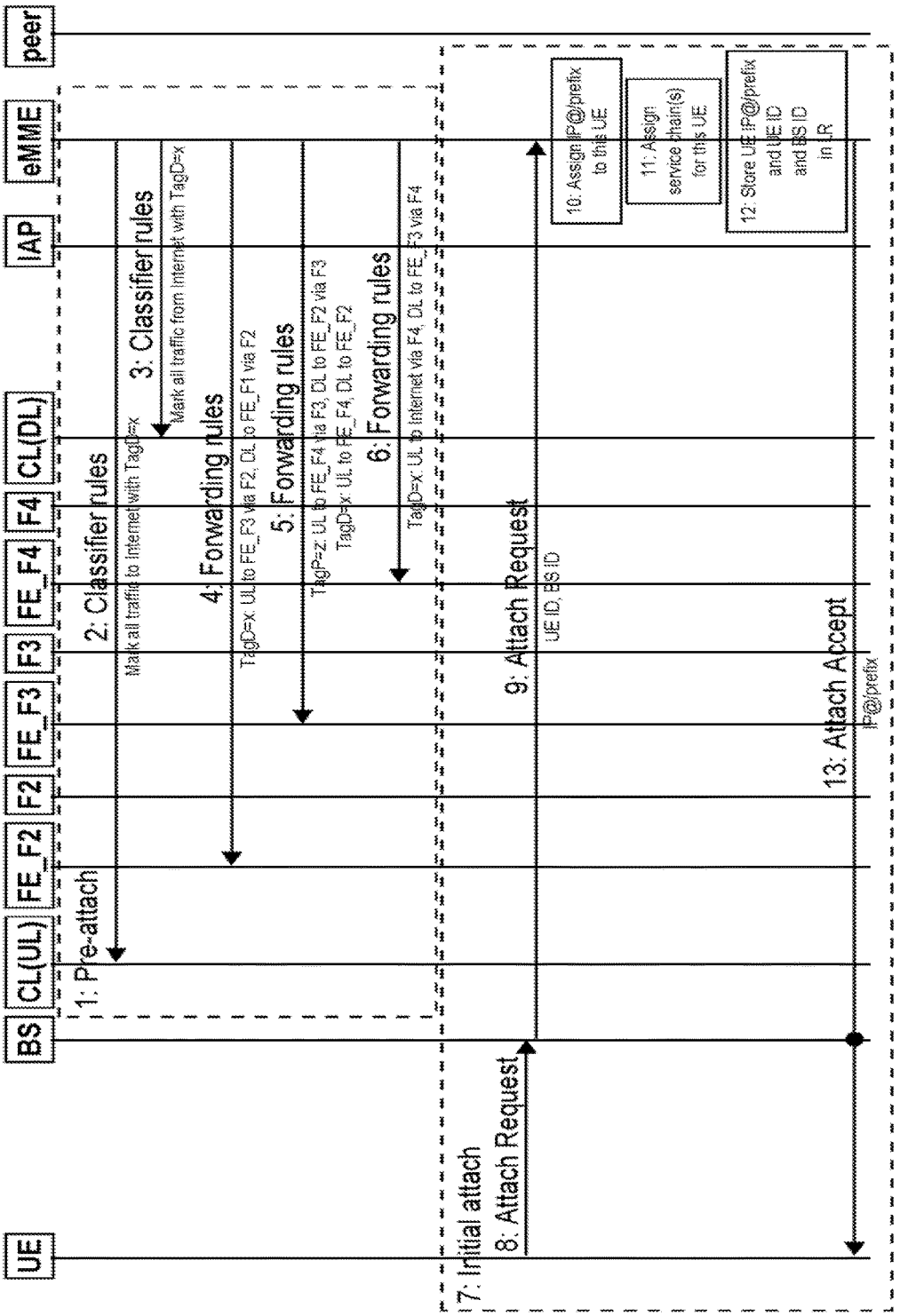

UE
BS
CL(UL)
F2
F3
F4
CL(DL)
IAP
eMME
peer
1: User plane traffic example
2: IP packet
src=UE IP@, dst=peer
3: IP packet
src=UE IP@, dst=peer
4: Classify: set TagD=x
5: IP packet
TagD=x
src=UE IP@, dst=peer
6: IP packet
src=UE IP@, dst=peer
7: IP packet
src=peer, dst=UE IP@
8: If no cached marking rules for UE IP@
9: Request markings
UE IP@
10: Reply
UE ID, BS ID
11: IP packet
TagUE='UE ID', TagBS='BS ID'
src=peer, dst=UE IP@
12: Classify: set TagD=x
13: IP packet
TagD=x, TagUE='UE ID', TagBS='BS ID'
src=peer, dst=UE IP@
14: IP packet
TagUE='UE ID', TagBS='BS ID'
src=peer, dst=UE IP@
15: IP packet
src=peer, dst=UE IP@

Fig. 11


UE
BS
CL(UL)
FE_F2
F2
FE_F3
F3
FE_F4
F4
CL(DL)
IAP
eMME
peer
1: Pre-attach
2: Classifier rules
Mark all traffic to Internet with TagID=x
3: Classifier rules
Mark all traffic from Internet with TagID=x
4: Forwarding rules
TagID=x: UL to FE_F3 via F2, DL to FE_F1 via F2
5: Forwarding rules
TagP=Z: UL to FE_F4 via F3, DL to FE_F2 via F3
TagID=x: UL to FE_F4, DL to FE_F2
6: Forwarding rules
TagID=x: UL to Internet via F4, DL to FE_F3 via F4
7: Initial attach
8: Attach Request
9: Attach Request
UE ID, BS ID
10: Assign IP@/prefix to this UE
11: Assign service chain(s) for this UE
12: Store UE IP@/prefix and UE ID and BS ID in LR
13: Attach Accept
IP@/prefix

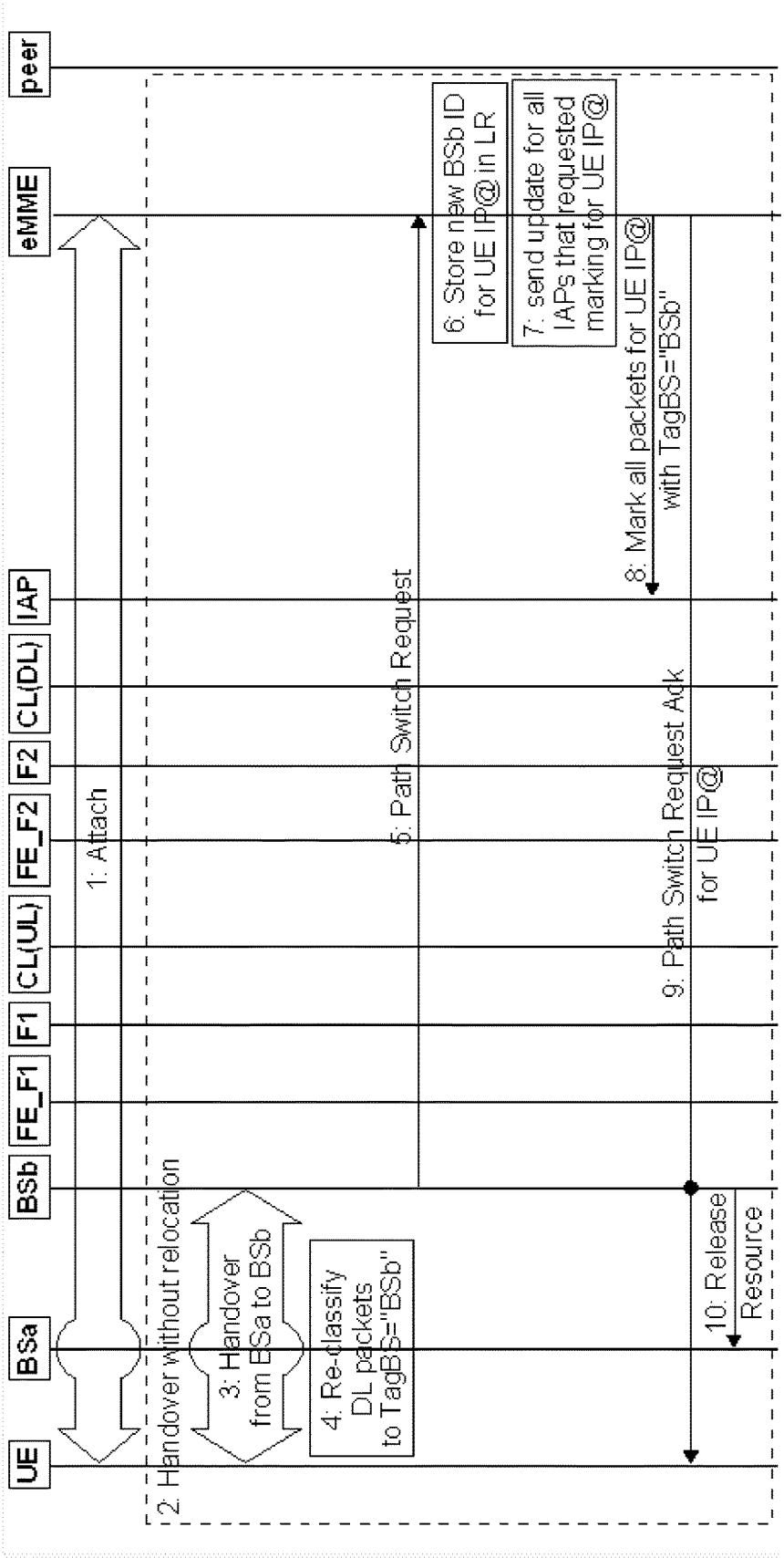

UE
BSa
BSb
FE_F1
F1
CL(UL)
FE_F2
F2
CL(DL)
IAP
eMME
peer
1: Attach
2: Handover without relocation
3: Handover from BSa to BSb
4: Re-classify DL packets to TagBS="BSb"
5: Path Switch Request
6: Store new BSb ID for UE IP@ in LR
7: send update for all IAPs that requested marking for UE IP@
8: Mark all packets for UE IP@ with TagBS="BSb"
9: Path Switch Request Ack for UE IP@
10: Release Resource

Fig. 12a

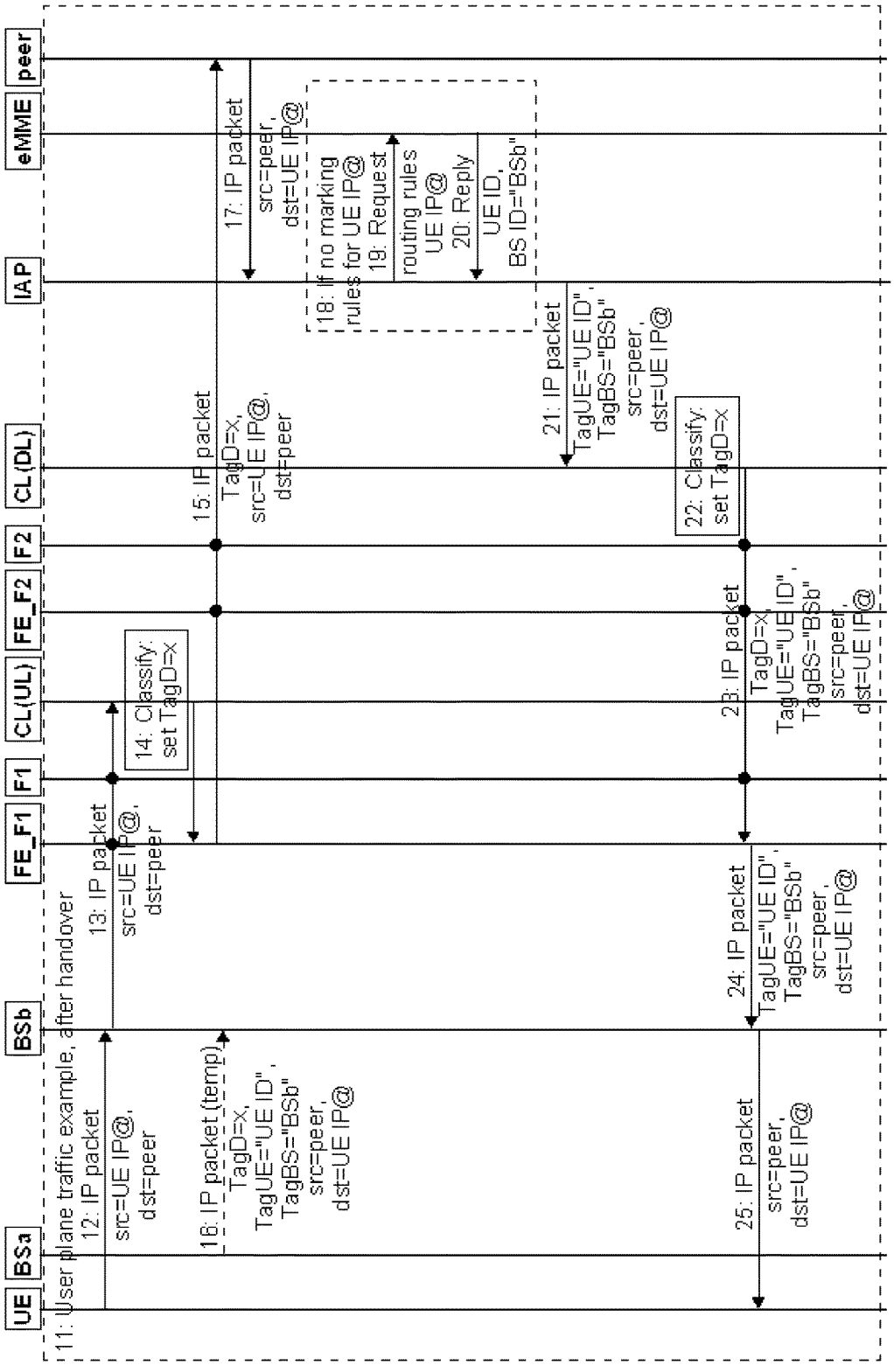

UE
BSa
BSb
FE_F1
F1
CL(UL)
FE_F2
F2
CL(DL)
IAP
eMME
peer
11: User plane traffic example, after handover
12: IP packet
src=UE IP@,
dst=peer
13: IP packet
src=UE IP@,
dst=peer
14: Classify:
set TagD=x
15: IP packet
TagD=x,
src=UE IP@,
dst=peer
16: IP packet (temp)
TagD=x,
TagUE="UE ID",
TagBS="BSb"
src=peer,
dst=UE IP@
17: IP packet
src=peer,
dst=UE IP@
18: If no marking
rules for UE IP@
19: Request
routing rules
UE IP@
20: Reply
UE ID,
BS ID="BSb"
21: IP packet
TagUE="UE ID",
TagBS="BSb"
src=peer,
dst=UE IP@
22: Classify:
set TagD=x
23: IP packet
TagD=x,
TagUE="UE ID",
TagBS="BSb"
src=peer,
dst=UE IP@
24: IP packet
TagUE="UE ID",
TagBS="BSb"
src=peer,
dst=UE IP@
25: IP packet
src=peer,
dst=UE IP@

Fig. 12b

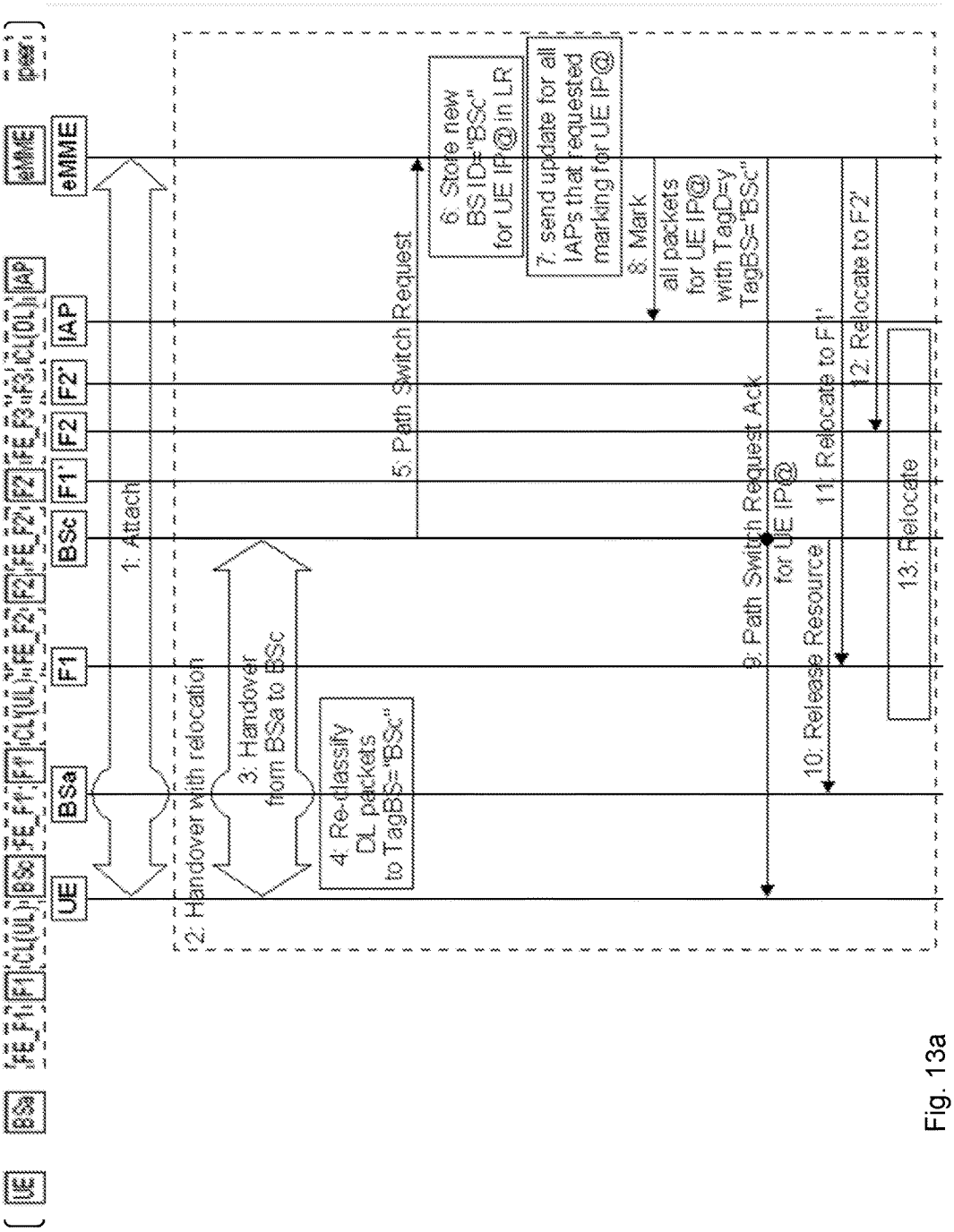

UE
BSa
F1
BSc
F1'
F2
F2'
IAP
eMME
1: Attach
2: Handover with relocation
3: Handover from BSa to BSc
4: Re-classify DL packets to TagBS="BSc"
5: Path Switch Request
6: Store new BS ID="BSc" for UE IP@ in LR
7: send update for all IAPs that requested marking for UE IP@
8: Mark all packets for UE IP@ with TagID=y TagBS="BSc"
9: Path Switch Request Ack for UE IP@
10: Release Resource
11: Relocate to F1'
12: Relocate to F2'
13: Relocate

Fig. 13a

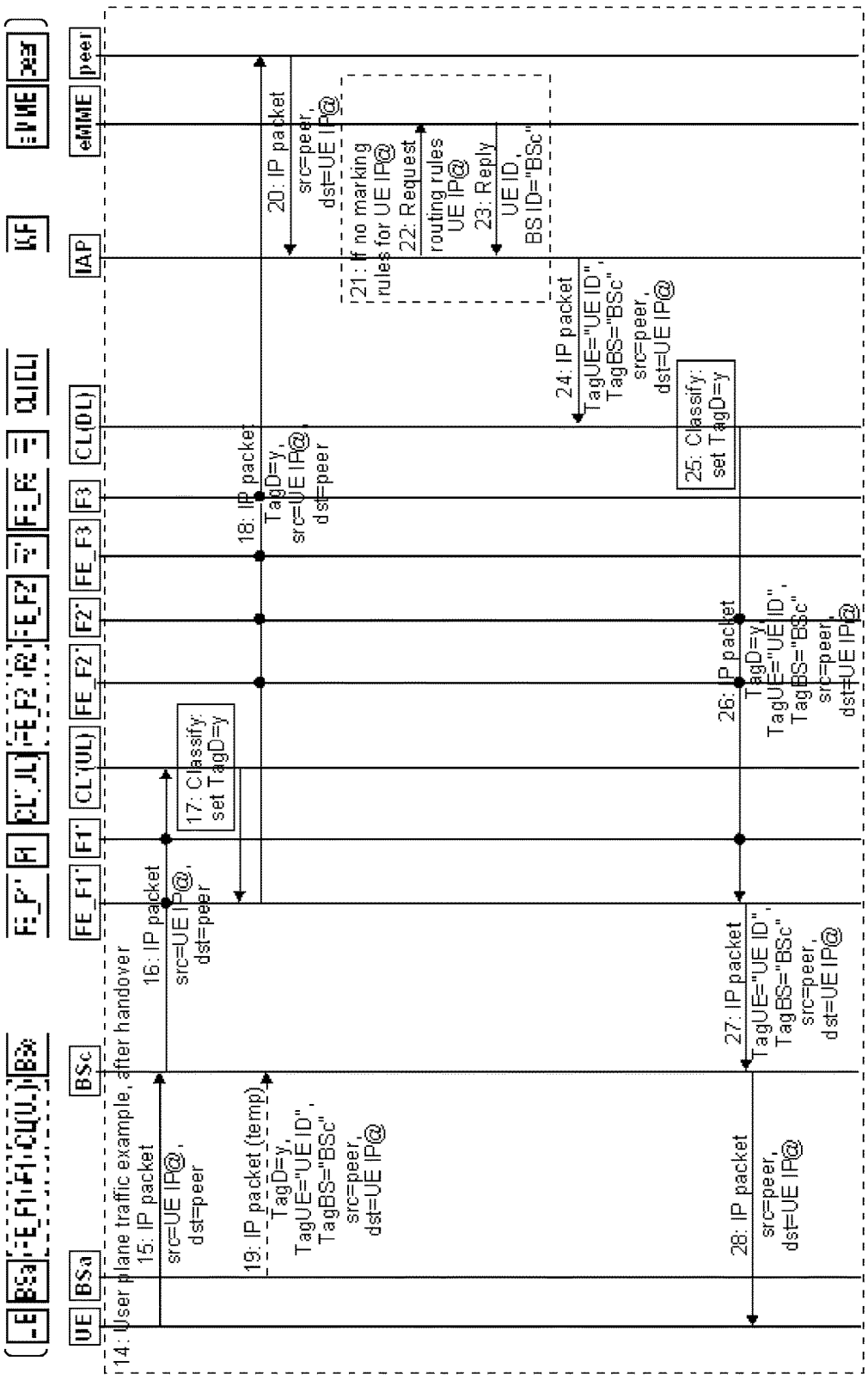

UE
BSa
BSc
FE_F1'
F1'
CL'(UL)
FE_F2'
F2'
FE_F3
F3
CL(DL)
IAP
eMME
peer
14: User plane traffic example, after handover
15: IP packet
src=UE IP@,
dst=peer
16: IP packet
src=UE IP@,
dst=peer
17: Classify:
set TagD=y
18: IP packet
TagD=y,
src=UE IP@,
dst=peer
19: IP packet (temp)
TagD=y,
TagUE="UE ID",
TagBS="BSc",
src=peer,
dst=UE IP@
20: IP packet
src=peer,
dst=UE IP@
21: if no marking
rules for UE IP@
22: Request
routing rules
UE IP@
23: Reply
UE ID,
BS ID="BSc"
24: IP packet
TagUE="UE ID",
TagBS="BSc",
src=peer,
dst=UE IP@
25: Classify:
set TagD=y
26: IP packet
TagD=y,
TagUE="UE ID",
TagBS="BSc",
src=peer,
dst=UE IP@
27: IP packet
TagUE="UE ID",
TagBS="BSc",
src=peer,
dst=UE IP@
28: IP packet
src=peer,
dst=UE IP@

Fig. 13b

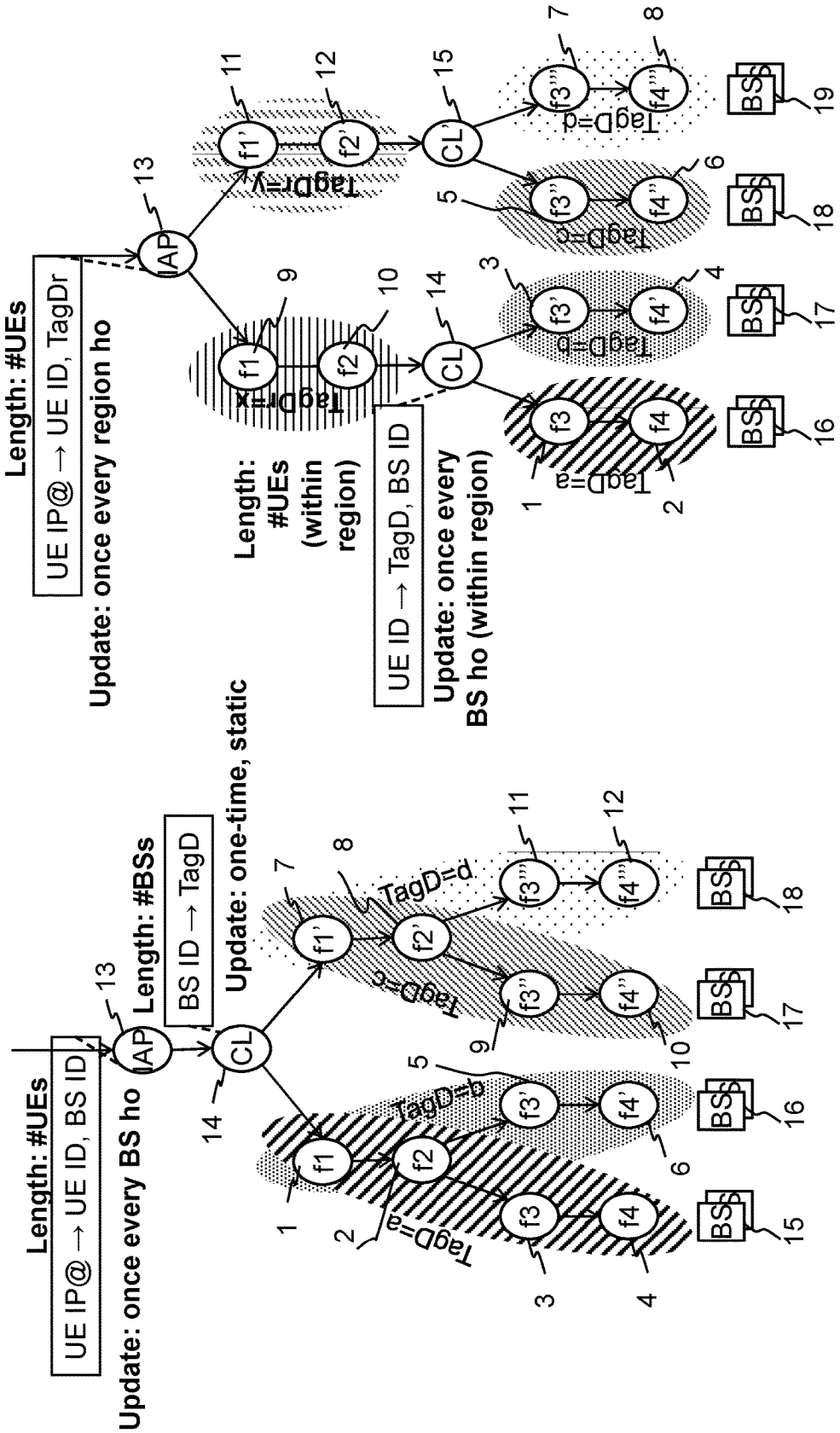


Fig. 14a

Fig. 14b

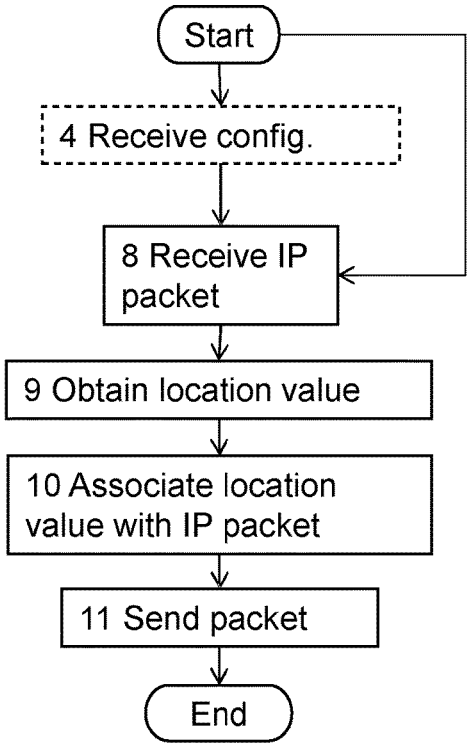

Start
4 Receive config.
8 Receive IP packet
9 Obtain location value
10 Associate location value with IP packet
11 Send packet
End

Fig. 15

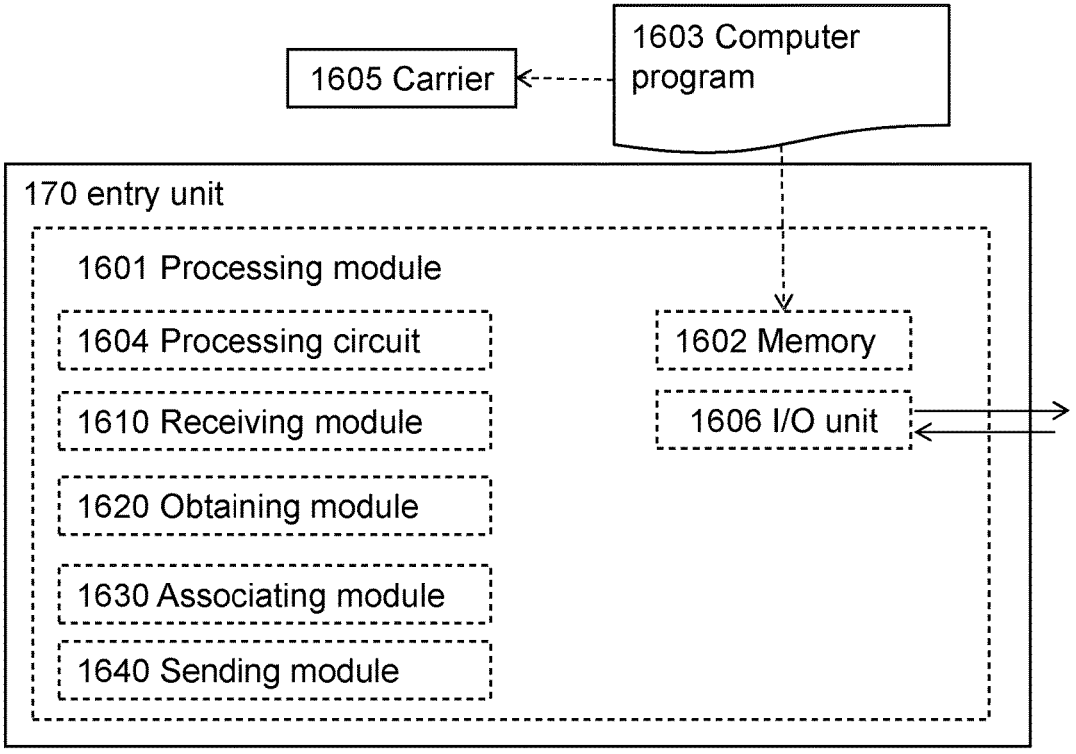

1603 Computer program
1605 Carrier
170 entry unit
1601 Processing module
1604 Processing circuit
1602 Memory
1610 Receiving module
1606 I/O unit
1620 Obtaining module
1630 Associating module
1640 Sending module

Fig. 16

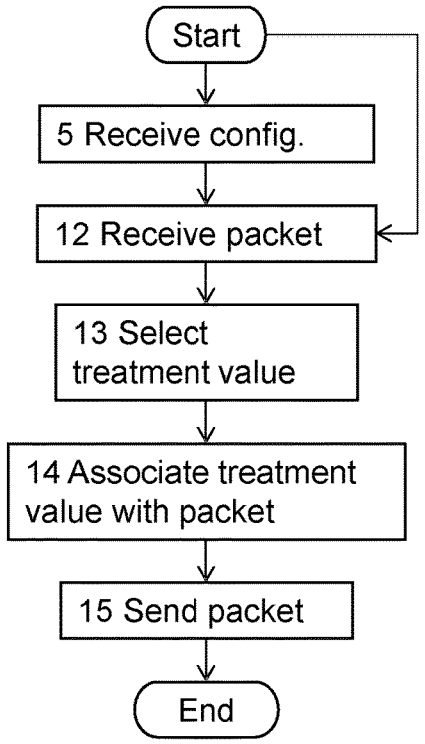

Start
5 Receive config.
12 Receive packet
13 Select treatment value
14 Associate treatment value with packet
15 Send packet
End

Fig. 17

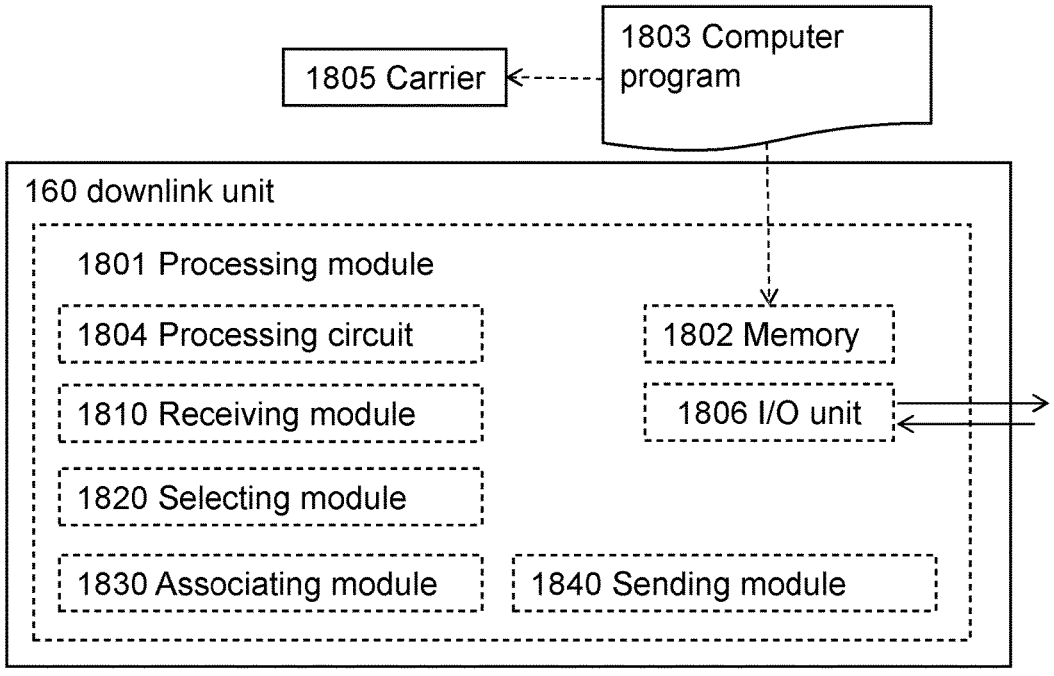

1803 Computer program
1805 Carrier
160 downlink unit
1801 Processing module
1804 Processing circuit
1802 Memory
1810 Receiving module
1806 I/O unit
1820 Selecting module
1830 Associating module
1840 Sending module

Fig. 18

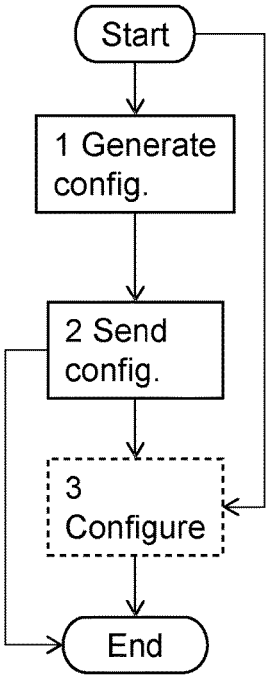

Start
1 Generate config.
2 Send config.
3 Configure
End

Fig. 19

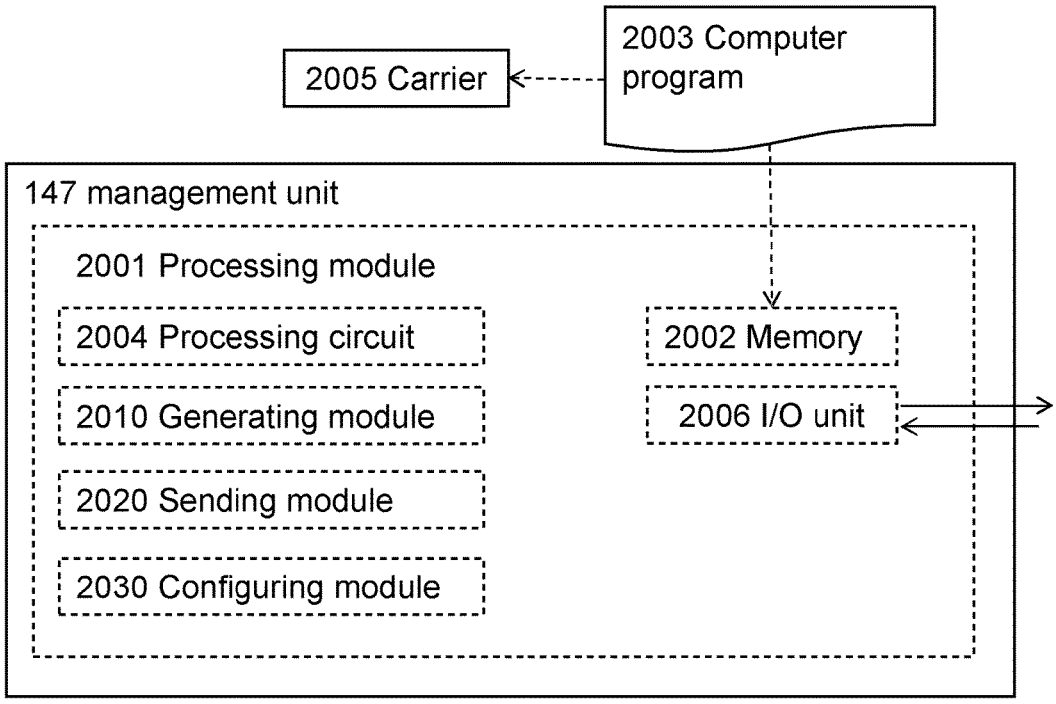

2003 Computer program
2005 Carrier
147 management unit
2001 Processing module
2004 Processing circuit
2002 Memory
2010 Generating module
2006 I/O unit
2020 Sending module
2030 Configuring module

Fig. 20

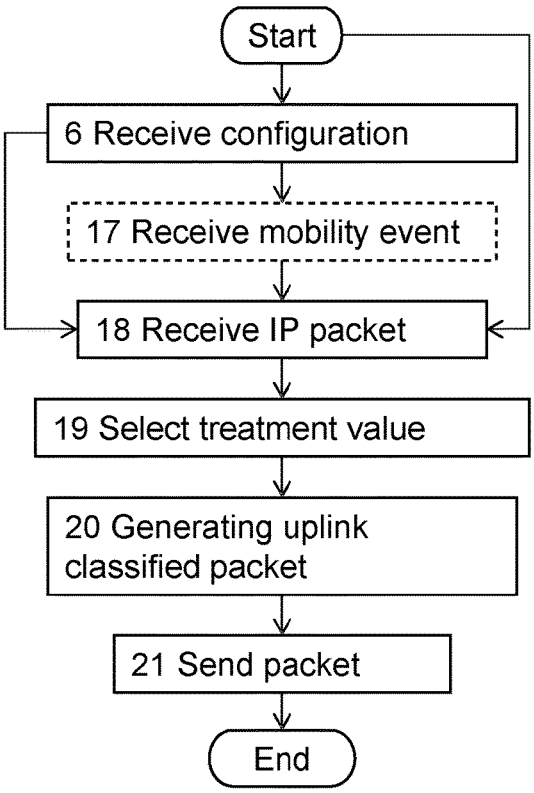

Start
6 Receive configuration
17 Receive mobility event
18 Receive IP packet
19 Select treatment value
20 Generating uplink classified packet
21 Send packet
End

Fig. 21

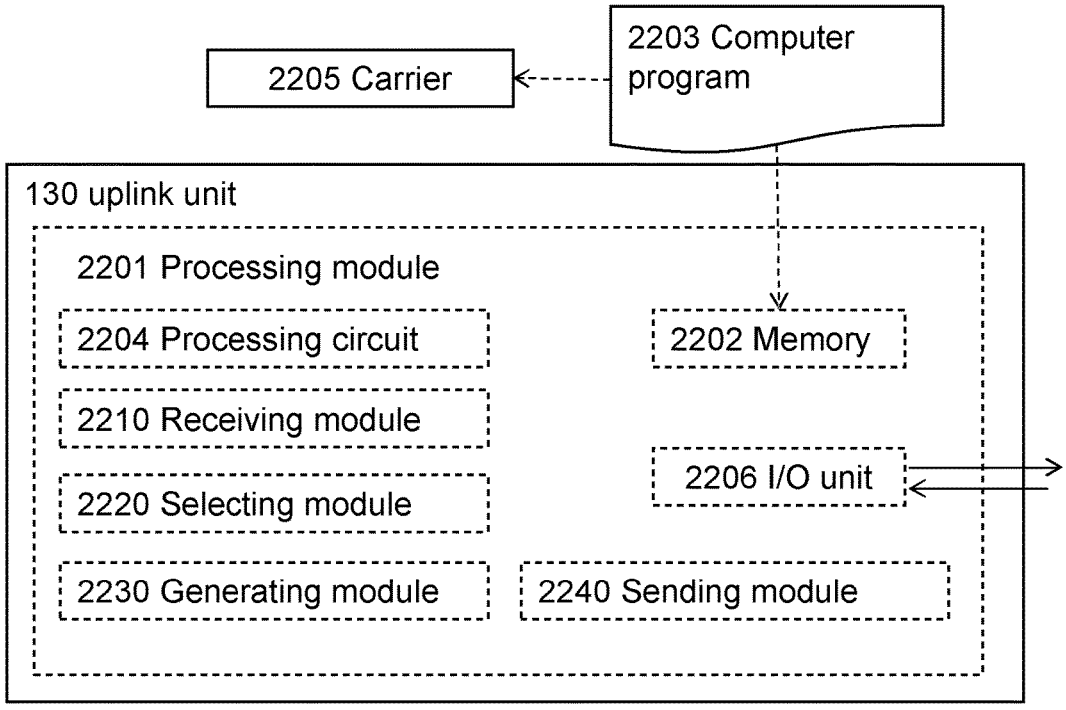

2203 Computer program
2205 Carrier
130 uplink unit
2201 Processing module
2204 Processing circuit
2202 Memory
2210 Receiving module
2206 I/O unit
2220 Selecting module
2230 Generating module
2240 Sending module

Fig. 22

METHODS AND MODULES FOR MANAGING PACKETS IN A SOFTWARE DEFINED NETWORK

TECHNICAL FIELD

[0001] Embodiments herein relate to communication systems, such as wireless communication systems. In particular, methods and modules for managing packets in a communication system based on Software Defined Networking are disclosed.

BACKGROUND

[0002] Today's mobile network architecture, a so called Evolved Packet Core (EPC) architecture, is described in Third Generation Partnership Project (3GPP) Technical Specification (TS) 23.401 and 3GPP TS 23.402. An overview of the EPC architecture **100** is illustrated in FIG. **1**. An user equipment (UE) **101** (or mobile device) attaches to a network, e.g. via a radio access network such as evolved-UMTS Terrestrial Radio Access Network (UTRAN) **102**, where UMTS stands for Universal Mobile Telecommunications System, and receives an Internet Protocol (IP) address. The UE uses that IP address to communicate with peers on a Packet Data Network (PDN) **103**. Such PDN is in most cases the Internet, but could also be an operator's IP service like IP Multimedia Subsystem (IMS), Public-switched telephone network Simulation Subsystem (PSS) or the like. The PGW (PDN Gateway) **104** provides access towards one or more PDNs **103**. There is a logical IP tunnel, called PDN connection, between UE and PGW.

[0003] All traffic of a PDN connection is routed through one and the same PGW **104**. The IP address of that PDN connection, i.e. the UE's IP address, topologically belongs to the PGW **104**. The PGW **104** thus acts as an anchor point for that IP address. Wherever the UE **101** moves, the anchor point remains the same. This way the peer on Internet, such as the PDN **103**, does not notice the movement of the UE **101**.

[0004] A PDN connection consists of three segments: the segment between UE and Base Station (BS), in FIG. **1** denoted as E-UTRAN **102**, the segment between the BS **102** and SGW (Serving Gateway) **105**, and the segment between the SGW **105** and the PGW **104**. The latter two are implemented by General Packet Radio Service (GPRS) Tunnelling Protocol (GTP) tunneling (http://en.wikipedia.org/wiki/GPRS_Tunnelling Protocol). E.g. a downstream IP user data packet (i.e. a packet towards the UE) between the PGW **104** and the SGW **105** is encapsulated in a GTP header and an outer IP transport header. The GTP header contains a Tunnel Endpoint ID (TEID) indicating which user, i.e. which UE **101**, this packet belongs to. The outer IP transport header has the SGW **105** has destination address. There is a similar setup between the SGW **105** and the BS**102**, but there a downlink packet has the BS address set as destination address in the transport IP header.

[0005] FIG. **1** illustrates further entities, such as Mobility Management Entity (MME) **106**, Home Subscription System (HSS) **107**, Serving GPRS Support Node (SGSN) **108**, Policy and Charging Rules Function (PCRF) **109** for completeness. Moreover, two other exemplifying radio access networks, i.e. UTRAN **110** and GSM EDGE Radio Access Network (GERAN) **111**, where GSM denotes Global System for mobile communication and EDGE denotes Enhanced Data Rates for GSM Evolution, are shown.

[0006] On transport level there may be additional layers, not shown in FIG. **1**. E.g. the BS **102** and the SGW **105** may be in different sites, and the transport of packets between the sites may be performed through an encrypted transport tunnel. In such a setup, there may be a security gateway on both ends of the transport tunnel performing the encryption and decryption.

[0007] In order to fulfill upcoming requirements on the EPC architecture **100**, it is believed that a completely redesigned architecture is required.

[0008] One such redesigned architecture is proposed to be based on Software Defined Networking (SDN). With software defined networking, a so called control plane is separated from a so called user plane, or data plane. A vision is that such architecture leads to a cheaper and more flexible network deployment. Networking services, such as network address translation, deep packet inspection, access control and the like, are no longer provided as monolithic boxes, but split up into the user plane performing the forwarding of user plane packets, and the control plane instructing the user plane how to perform the forwarding. A route, or path, that packets of a specific user, or even a specific flow of a user, takes through a collection of user plane forwarding elements is also known as a service chain.

[0009] Service chaining is today mainly used in a context where the end device does not move from a service chaining perspective. Typically, this is a fixed network environment or a mobile network where service chaining is used only above an anchor point.

[0010] In a service chaining environment where the end device does move, as would be the case when SDN is used in the above mentioned redesigned core architecture for a mobile wireless communication system, some new requirements are placed on the forwarding of the packets of that device. In particular, packets may get forwarded by a different set of forwarding elements after the moving. This implies that some kind of re-configuration is needed in order to forward the packets of that device to the new location of that device.

[0011] Consider the network example in FIG. **2**, in which a device, i.e. a UE such as a UEa **201** in the Figure, moves from a source base station (BS**1**) **202** to a target base station (BS**3**) **204**. There are four base stations **202**-**205** and a number of Forwarding Elements (FEs), i.e. FE**1** **206** though FE**7** **212**. The Forwarding Elements FE**1**-FE**7** **206**-**212** may be organized in this way for topological reasons; i.e. a first Forwarding Element (FE**1**) **206** may be close to the source base station (BS**1**) **202** but far from the target base station (BS**3**) **204**.

[0012] Let's assume that the UEa **201** communicates with a peer **213**, such as a computer, another UE, a server or the like, behind a further Forwarding Element (FE**7**) **212**. In a naive implementation, each Forwarding Element in the UE-peer chain (of Forwarding Elements: FE**1** **206**-FE**2** **207**-FE**5** **210**-FE**6** **211**-FE**7** **212**) will have at least one entry for the UEa **201**. Worst case, there may be a single entry for every flow of the UEa **201**. Now assume that the UEa **201** moves from the BS**1** **202** to the BS**3** **204**. This would require new entries for the UEa **201** in a third Forwarding Element (FE**3**) **208** and a fourth Forwarding Element (FE**4**) **209**. It would also require an update to the UEa **201** entries in a fifth Forwarding Element (FE**5**) **210**, such that packets towards

the UEa **201** are now forwarded to the FE**4** **209** instead of to a second Forwarding Element (FE**2**) **207**. And finally, the entries of the UEa **201** in a first Forwarding Element (FE**1**) **202** and theFE **2** **207** would need to be removed. All this causes a lot of control plane signaling towards the Forwarding Elements and node(s) controlling the Forwarding Elements. This is not a scalable solution.

[0013] SoftCell (ftp://ftp.cs.princeton.edu/techreports 2013/950. proposes one solution to this scalability problem. FIG. **3** is used to explain how the aspect of mobility with service chaining is solved in the SoftCell approach.

[0014] SoftCell defines an Access Switch (AS), such as AS**2320**, AS **2** **321**, AS**3** **322** and AS**4** **324** in FIG. **3**, that are close to base stations, such as a source base station (BS**1**) **310**. The Access Switch is logically located between the base stations and first Forwarding Elements, such as FE**1** **340** and FE**3** **342**. The AS could be co-located with the BS, and could in fact be the first Forwarding Elements, again such as FE **1** **340** and FE**3** **2** combined with a User Plane Function (UPF). In this terminology, the Forwarding Element performs solely the packet forwarding and the UPF performs some kind of operation on the packet and may even alter the packet. Combined they may perform one of the network services mentioned above.

[0015] The AS performs packet classification on traffic of UEs. Each packet is mapped to a policy. The policy defines which chain that packet belong to; i.e. which FEs and UPFs that packet needs to traverse. Packets are then aggregated onto three dimensions: policy, location (a base station ID) and UE ID. These aggregation dimensions can then selectively be used thereby limiting the number of entries in the FEs. E.g., FE**5** **344** in the figure above can base its downlink forwarding decisions on the location dimension, and does not need to take the UE dimension into account. FE **345** can base its uplink forwarding decision on the policy dimension, and does not need to take into account the location and UE dimension.

[0016] SoftCell proposes to code the three dimensions of policy, base station ID and UE ID in the source IP address and port of uplink packets. It is the AS that does this encoding. So the AS translates the source IP address and port used by the UE into a new source IP address and port, similar to a Network Address Translation (NAT) function. Between AS and peer this new IP address and port pair is used. The downlink packet from the peer includes new IP address and port as destination address. As the IP address topologically belongs to the AS, the downlink packet will arrive at the same AS. The AS then translates back to the original IP address and port known by the UE.

[0017] Now assume that a device, such as a UEa **301**, moves from the BS**1** **310** to the BS**2** **311** in FIG. **3**. The UEa **301** would thus move from a first Access Switch (AS**1**) **320** to a second Access Switch (AS**2**) **321**. SoftCell proposes to keep existing flows routed via the AS**1** **320**, in order to avoid a perceived IP address change for ongoing flows. So, for a flow that started when the UEa **301** was still on the BS**1** **310**, the flow gets routed via the BS**2** **311** and the AS**1** **320** after the move. Only new flows get routed via the BS**2** **311** and the AS **2** **321**.

[0018] The SoftCell approach has a couple of disadvantages:

[0019] The encoding of the three dimensions into an IP address and port pair only works for flows that originate from the UEa **301**. Because the peer is not aware of any encoding scheme, the SoftCell approach does not work for flows that originate from the peer.

[0020] After the UEa **301** has moved to a new BS, such as the BS**2** **311**, existing flows are still routed via the AS**1** **320** associated with the old BS, i.e. the BS**1** **310**. This introduces sub-optimal routing of such flows. This is in particular a disadvantage for long-lasting flows.

[0021] Assume that the UEa **301** has a number of active flows towards a peer. It then moves to a new BS, such as the BS**2** **311**, and starts an additional flow. Then the peer **350** will perceive a new source address for the additional flow, even though that flow originates from the same UEa **301**. This may confuse the peer **350** in certain scenarios.

[0022] SoftCell is basically introducing a Network Address Translation (NAT). This is acceptable for IPv**4**, as there already are so many NATs employed for IPv**4** anyway, but is less appealing for IPv**6**.

[0023] Another solution is needed that removes these limitations from SoftCell, while at the same time keeping the advantages of SoftCell; i.e. scalable signaling towards the Forwarding Elements by aggregating flows.

SUMMARY

[0024] An object may be to improve performance of the above mentioned communication system, such as a communication system utilizing Software Defined Networking.

[0025] According to an aspect, the object is achieved by a method, performed by an entry module, for managing packets in a communication system based on Software Defined Networking, wherein the communication system comprises the entry module, a radio network node, a mobile device, a forwarding module, a service module, a peer device and a management module for managing the forwarding module, the service module and the entry module, wherein a data plane of the communication system comprises the forwarding module, the service module and the entry module and a control plane of the communication system comprises the management module, wherein the mobile device is attached to the radio network node. The entry module receives an IP packet from the peer device, wherein the IP packet includes a destination IP address associated with the mobile device. The entry module obtains, from the management module, a location value specifying the radio network node associated with the destination IP address. The entry module associates the location value with the IP packet, wherein the location value is related to a location tag name, indicating the radio network node that serves the mobile device, thereby obtaining a packet. Furthermore, the entry module sends the packet, via the forwarding module, towards the radio network node as indicated by the location value of the location tag name.

[0026] According to another aspect, the object is achieved by an entry module configured to manage packets in a communication system based on Software Defined Networking, wherein the communication system comprises the entry module, a radio network node, a mobile device, a forwarding module, a service module, a peer device and a management module for managing the forwarding module, the service module and the entry module, wherein a data plane of the communication system comprises the forwarding module, the service module and the entry module and a control plane of the communication system comprises the

management module, wherein the mobile device is attached to the radio network node, wherein the entry module is configured for: receiving an IP packet from the peer device, wherein the IP packet includes a destination IP address associated with the mobile device; obtaining, from the management module, a location value specifying the radio network node associated with the destination IP address; associating the location value with the IP packet, wherein the location value is related to a location tag name, indicating the radio network node that serves the mobile device, thereby obtaining a packet; and sending the packet, via the forwarding module, towards the radio network node as indicated by the location value of the location tag name.

[0027] According to a further aspect, the object is achieved by a method, performed by a downlink module, for managing packets in a communication system based on Software Defined Networking, wherein the communication system comprises the downlink module, a radio network node, a mobile device, a forwarding module, a service module, a peer device and a management module for managing the forwarding module and the service module, wherein a data plane of the communication system comprises the downlink module, the forwarding module and the service module and a control plane of the communication system comprises the management module, wherein the mobile device is attached to the radio network node. The downlink module receives, from the management module, second configuration information indicating a treatment tag name, and treatment values. The downlink module receives, via the entry module, a packet from the peer device. The downlink module selects a treatment value out of the treatment values based on information included in the packet, thereby classifying the packet. The downlink module associates the treatment value with the packet, wherein the treatment value is related to the treatment tag name. The downlink module sends the packet and the associated treatment value, via the forwarding module which performs the treatment of the packet according to the treatment value, towards the radio network node.

[0028] According to yet another aspect, the object is achieved by a downlink module configured to manage packets in a communication system based on Software Defined Networking, wherein the communication system comprises the downlink module, a radio network node, a mobile device, a forwarding module, a service module, a peer device and a management module for managing the forwarding module and the service module, wherein a data plane of the communication system comprises the downlink module, the forwarding module and the service module and a control plane of the communication system comprises the management module, wherein the mobile device is attached to the radio network node, wherein the downlink module is configured for: receiving, from the management module, second configuration information indicating a treatment tag name, and treatment values, performed by the forwarding module, of the packets; receiving, via the entry module, a packet from the peer device; selecting a treatment value out of the treatment values based on information included in the packet, thereby classifying the packet; associating the treatment value with the packet, wherein the treatment value is related to the treatment tag name; and sending the packet and the associated treatment value, via the forwarding module which performs the treatment of the downlink classified packet according to the treatment value, towards the radio network node.

[0029] According to a still further aspect, the object is achieved by a method, performed by a management module, for managing configuration information in a communication system based on Software Defined Networking, wherein the communication system comprises an entry module, a downlink module, a forwarding module, and an uplink module, wherein a data plane of the communication system comprises the forwarding module and a control plane of the communication system comprises the management module. The management module generates first configuration information and/or second configuration information, wherein the first configuration information indicates a location tag name and location values, wherein each location value is associated to a respective radio network node to which the mobile device is capable of attaching, and/or the second configuration information indicates a treatment tag name and treatment values and a rule for treatment, performed by the forwarding module, of the packets. The management module sends the first configuration information to the entry module and/or sending the second configuration information to the downlink module and/or the uplink module.

[0030] According to yet a further aspect, the object is achieved by a management module configured to manage configuration information in a communication system based on Software Defined Networking, wherein the communication system comprises an entry module, a downlink module, a forwarding module, and an uplink module, wherein a data plane of the communication system comprises the forwarding module and a control plane of the communication system comprises the management module, wherein the management module is configured for: generating first configuration information and/or second configuration information, wherein the first configuration information indicates a location tag name and location values, wherein each location value is associated to a respective radio network node to which the mobile device is capable of attaching, and/or the second configuration information indicates a treatment tag name and treatment values and a rule for treatment, performed by the forwarding module, of the packets; and sending the first configuration information to the entry module and/or sending the second configuration information to the downlink module and/or the uplink module.

[0031] According to still another aspect, the object is achieved by a method, performed by an uplink module, for managing packets in a communication system based on Software Defined Networking, wherein the communication system comprises the uplink module, a radio network node, a mobile device, a forwarding module, a service module, a peer device and a management module for managing the forwarding module and the service module, wherein a data plane of the communication system comprises the uplink module, the forwarding module and the service module and a control plane of the communication system comprises the management module, wherein the mobile device is attached to the radio network node. The uplink module receives, from the management module, second configuration information indicating a treatment tag name, and treatment values. The uplink module receives, via the radio network node, an IP packet from the mobile device. The uplink module selects a treatment value out of the treatment values based on information included in the packet, thereby classifying the IP

packet. The uplink module generates an uplink classified packet encapsulating the treatment value and the IP packet, wherein the treatment value is related to the treatment tag name. The uplink module sends the uplink classified packet, via the forwarding module which performs the treatment of the uplink classified packet according to the treatment value, towards the peer device.

[0032] According to a yet further aspect, the object is achieved by an uplink module configured for managing packets in a communication system based on Software Defined Networking, wherein the communication system comprises the uplink module, a radio network node, a mobile device, a forwarding module, a service module, a peer device and a management module for managing the forwarding module and the service module, wherein a data plane of the communication system comprises the uplink module, the forwarding module and the service module and a control plane of the communication system comprises the management module, wherein the mobile device is attached to the radio network node, wherein the uplink module is configured for: receiving, from the management module, second configuration information indicating a treatment tag name, and treatment values; receiving, via the radio network node, an IP packet from the mobile device; selecting a treatment value out of the treatment values based on information included in the packet, thereby classifying the IP packet; generating an uplink classified packet encapsulating the treatment value and the IP packet, wherein the treatment value is related to the treatment tag name; and sending the uplink classified packet, via the forwarding module which performs the treatment of the uplink classified packet according to the treatment value, towards the peer device.

[0033] According to further aspects, the object is achieved by computer programs and carriers for the computer programs corresponding to the aspects above.

[0034] Embodiments herein provide a scalable solution for mobility in combination with service chaining. The embodiments herein are applicable to a core network architecture, where the management module may handle a location registry that is kept up-to-date with the current location of each mobile device, i.e. user equipment, as described in the detailed description below. The location registry may be implemented in several ways, including in a distributed fashion, e.g. within a control plane.

[0035] With the embodiments herein, packets are marked, or associated, with one or more tags, where a tag has a tag name and a value. A combination of tags defines a path through a SDN, comprising the first and/or downlink modules, for that packet. Aggregation of entries, e.g. tag names, may be achieved by using the same tag for multiple flows and multiple devices, thereby limiting the number of entries in the forwarding elements of the service chain, aka route or path. Packets are tagged by one or more modules, such as the first and downlink modules.

[0036] At a mobility event, when the mobile device has moved to a new location, at least one entry module, and possibly also one or more downlink modules, gets updated such that packets for that device get marked with the same tag names, such as the location tag name, but where one or more tags have an updated value, i.e. the location value. The updated value reflects the new location of the mobile device, e.g. reflects the radio network node serving the mobile device at the new location.

[0037] Forwarding modules may be configured on how packets with a specific tag are to be forwarded. Most of this configuration, and in typical cases all configuration, does not need to be updated, i.e. performed again, upon mobility events. This keeps control signaling towards the forwarding modules at, or near, a minimum, or at least low.

[0038] The embodiments herein provide a scalable approach to the problem of mobility in connection with service chaining for packets of flows in both uplink and downlink direction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0039] The various aspects of embodiments disclosed herein, including particular features and advantages thereof, will be readily understood from the following detailed description and the accompanying drawings, in which:

[0040] FIG. **1** is a schematic overview of an Evolved Packet Core architecture,

[0041] FIG. **2** is a block diagram illustrating base stations and forwarding element of a software defined network,

[0042] FIG. **3** is a further block diagram illustrating base stations and forwarding element of a software defined network,

[0043] FIG. **4** is a schematic overview of an exemplifying system in which embodiments herein may be implemented,

[0044] FIG. **5** is a block diagram illustrating encapsulation of packets,

[0045] FIG. **6** is a combined signaling and flowchart illustrating the methods herein,

[0046] FIG. **7** is an illustration of a software defined network according to embodiments herein,

[0047] FIG. **8** is a block diagram illustrating network set up for a mobile broadband use case,

[0048] FIG. **9** is a further block diagram illustrating an exemplifying network set up,

[0049] FIG. **10** is a further combined signaling and flowchart illustrating an embodiment herein,

[0050] FIG. **11** is a still further combined signaling and flowchart illustrating a further embodiment herein,

[0051] FIGS. **12***a* and **12***b* are yet further combined signaling and flowcharts illustrating a yet further embodiment herein,

[0052] FIGS. **13***a* and **13***b* are yet still further combined signaling and flowcharts illustrating a yet still further embodiment herein,

[0053] FIGS. **14***a* and **14***b* are schematic overviews illustrating two different hierarchies,

[0054] FIG. **15** is a flowchart illustrating embodiments of the method in the entry module,

[0055] FIG. **16** is a block diagram illustrating embodiments of the entry module,

[0056] FIG. **17** is a flowchart illustrating embodiments of the method in the downlink module,

[0057] FIG. **18** is a block diagram illustrating embodiments of the downlink module,

[0058] FIG. **19** is a flowchart illustrating embodiments of the method in the management module,

[0059] FIG. **20** is a block diagram illustrating embodiments of the management module,

[0060] FIG. **21** is a flowchart illustrating embodiments of the method in the uplink module, and

[0061] FIG. **22** is a block diagram illustrating embodiments of the uplink module.

DETAILED DESCRIPTION

[0062] Throughout the following description similar reference numerals have been used to denote similar features, such as nodes, actions, steps, modules, circuits, parts, items elements, modules or the like, when applicable. In the Figures, features that appear in some embodiments are indicated by dashed lines.

[0063] FIG. **4** depicts an exemplifying communication system **100** in which embodiments herein may be implemented. The communication system **100** is similar to the network architecture shown in FIG. **7** and/or **9** below.

[0064] Accordingly, the communication system **100** is a schematic example of a proposed architecture for a packet core network for 5G (5^{th} Generation mobile communication systems). p The communication system **100** is based on Software Defined Networking. This means that the communication system uses SDN technologies, i.e. the system extends a basic SDN architecture by providing further functional modules in the user plane.

[0065] The communication system **100** comprises a control plane and a user plane. Within the communication system **100** the control plane is physically separated from the user plane. The control plane and the user plane may comprise one or more functional modules, referred to as "modules" herein. The control plane, or a functional module therein, may control one or more functional modules in the user plane via an interface, such as OpenFlow or the like. The interface allows the control plane to manage the user plane by e.g. specifying rules for forwarding in the user plane.

[0066] The control plane may comprise a management module (MM) **147**, such as an eMME shown in FIG. **4**. The management module **147** may handle a Location Registry (LR) **148**. In some examples, the management module **147** and the Location Registry **148** may be co-located in a co-located management module (CMM) **149**.

[0067] The communication system **100** comprises a radio network node **110**, aka a base station, an uplink module (ULM) **130**, a forwarding module (FM) **140**, a service module (SM) **145**, a downlink module (DM) **160** and an entry module (EM) **170**.

[0068] The entry module **170** may be co-located with the downlink module **160**, thus forming a co-located downlink entry module (DEM) **150**. This means that the downlink classifier and the IAP may be separated or may be co-located.

[0069] As will be mentioned again, the communication system **100** is anchorless in that IP packets of a flow of IP packets into the communication system **100** are capable of entering the communication system **100** via more than one entry module **170**. In the Figures herein, only one entry module **170** is shown for reasons of simplicity.

[0070] The forwarding modules may be configured, e.g. by the management module **147**, in order to be aware of which tags to inspect and/or where to find certain tags. When the forwarding element has read, or checked, a tag, the forwarding element may know to which further forwarding element, or the radio network node **110**, it shall forward the checked packet, which may encapsulate an IP packet.

[0071] Furthermore, FIG. **4** illustrates a mobile device **120**, or a terminal. For simplicity only one radio network node is shown in Figure p **1**. FIG. **4** may be extended to show further radio network nodes as in FIG. **9** below in order to illustrate mobility of the user equipment **120** in a three-level tag hierarchy for a mobile broadband use case.

[0072] Additionally, FIG. **4** illustrates a peer, or a peer device **180**. The peer device **180** may be of the same or of a different kind as the user equipment **120**. An IP connection may have been established between the user equipment **120** and the peer device **180**. However, within the communication system **100** IP packets of the IP connection are encapsulated.

[0073] As used herein, the term "radio network node" may refer to an evolved Node B (eNB), a Radio Network Controller (RNC), a Radio Base Station (RBS), a control node controlling one or more Remote Radio Units (RRUs), an access point or the like.

[0074] The terms "wireless device", "terminal", "user equipment", a machine-to-machine (M2M) device, a mobile phone, a cellular phone, a Personal Digital Assistant (PDA) equipped with radio communication capabilities, a smartphone, a laptop or personal computer (PC) equipped with an internal or external mobile broadband modem, a tablet PC with radio communication capabilities, a portable electronic radio communication device, a sensor device equipped with radio communication capabilities or the like, are used interchangeably herein. The term "user" may indirectly refer to the wireless device. Sometimes, the term "user" may be used to refer to the user equipment or the like as above. It shall be understood that the user may not necessarily involve a human user. The term "user" may also refer to a machine, a software component or the like using certain functions, methods and similar.

[0075] FIG. **5** illustrates encapsulation of an IP packet, comprising an IP header and a payload. The IP packet **51** may e.g. be as defined in Internet Engineering Task Force (IETF) publication RFC **791**, which describes e.g. destination/source IP address and option fields of the IP packet **51**. A new packet-encapsulating the IP packet—includes a new header and the IP packet **51**. Throughout the present disclosure, a type of a packet refers to that the new packet has a different header than the IP packet **51**.

[0076] In some examples, the term packet may be used to describe any packet. In sub-examples to such some examples, it may be explained that such any packet may be of type "IP packet" or "new packet", i.e. which new packet has a header that is different from the header of the IP packet **51**.

[0077] FIG. **6** illustrates an exemplifying method according to embodiments herein when performed in connection with the communication system **100** of FIG. **1**.

[0078] The communication system **100** may be based on Software Defined Networking elements. This may mean that the communication system includes at least one forwarding module for managing packets by invoking one or more networking services associated to the forwarding element, and for forwarding packets towards the downlink and/or uplink module, e.g. passing another forwarding module. Ultimately, the packet reaches the mobile device **120** or the peer device **180** depending on whether the packet is forwarded uplink or downlink.

[0079] Moreover, the communication system **100** is anchorless, which means that downlink packets of the same flow may enter the communication system **100**, e.g. an operator's network, through multiple entry modules, and thus also through multiple different downlink modules. All downlink packets within the same flow takes the same path

through the communication system **100**, thus passing the same chain of service modules, or instances thereof, and reaches the same radio network node.

[0080] Notably, as mentioned, the communication system **100** may comprise one or more forwarding modules, each of which may invoke one or more service modules, also referred to as User Plane Functions, e.g. networking services. The service modules may be realized as multiple instances associated to different forwarding modules.

[0081] In some embodiments herein, there are three types of tags.

[0082] A first type of tag, TagUE or identity tag name of mobile device, may identify the user equipment, its value may be the IP address of the user equipment.

[0083] A second type of tag, TagBS or location tag name, may identify the base station, via which the user equipment may be reached, i.e. via which the user equipment may send/receive IP packets. Its value identifies to which radio network node the mobile device is attached.

[0084] A third type of tag, TagD, may identify a path for IP packets towards, or from, the user equipment. A value of TagD need not be the same for uplink IP packets and downlink IP packets. The third type of tag is referred to by the term "service tag name".

[0085] Its value identifies which treatment packets travelling in the communication system shall obtain.

[0086] The three types of tags are applied to IP packets throughout the path between the mobile device **120** and the peer device **180**, i.e. not only for a so called segment of the path.

[0087] To conclude, information to be provided by the tags include: a) which user/UE a packet belongs to; b) where a packet is heading (which BS), aka location tag; c) what service chain the packet should get, aka service tag. This information may be encoded in three tags, but it may also be encoded into two, one, or more than three tags.

[0088] The entry module **170** performs a method for managing packets in a communication system **100** based on Software Defined Networking.

[0089] The downlink module **160** performs a method for managing packets in a communication system **100** based on Software Defined Networking.

[0090] The management module **147** performs a method for managing configuration information in a communication system **100** based on Software Defined Networking.

[0091] The uplink module **130** performs a method for managing packets in a communication system **100** based on Software Defined Networking.

[0092] The IP packet may be associated with a flow of IP packets from the peer device **180** to the mobile device **120**, wherein at least some other IP packets of the flow are receivable by a further entry module of the communication system **100**. Typically, another flow of IP packets, i.e. a second flow associated with another IP address possibly related to the same mobile device, may enter the communication system via another entry module. Moreover, it shall be understood that once the mobile device moves in the communication system **100**, it may happen that the flow, i.e. a first flow of IP packets, is moved such that it passes through another entry module after the movement.

[0093] The communication system **100** is anchorless in that the entry module **170** is capable of being one of many entry modules for receiving the IP packet, with the destination IP address, into the communication system **100** from any communication network neighboring thereto.

[0094] One or more of the following actions may be performed in any suitable order.

[0095] Action 1-6 relates to configuration, by the management module, of the modules in the user plane.

[0096] Action 1

[0097] The management module **147** generates first configuration information. The first configuration information indicates a location tag name and location values, wherein each location value is associated to a respective radio network node to which the mobile device **120** is capable of attaching.

[0098] In this manner, the first configuration information, to be sent to the entry module **170**, may make the entry module **170** aware of possible location values and which ports of the entry module **170** are associated to the location values.

[0099] Additionally or alternatively, the management module **147** generates second configuration information.

[0100] The second configuration information may include information about which tags to use and possible values. For example, the second configuration information may include instructions what tag names and values to add to packets of a certain IP flow. E.g. "All packets towards Internet are tagged with TagD and value x". The second configuration information indicates a treatment tag name, such as 'TagD' above, and treatment values and a rule for treatment, performed by the forwarding module **140**, of the packets. The rule of the second configuration information may specify how to select a treatment value based on destination IP address and/or source IP address of a packet.

[0101] In further examples, the treatment value may be selected based on source or destination port. E.g. the port may reveal a service address, provided by the service module and carried by a packet. Then the packet may get a higher QoS, i.e. more prioritized treatment, if the packet carries certain services.

[0102] In yet further examples, packets to/from Wireless Local Area Network WLAN node may obtain different treatment than packets to/from a cellular base station, such as an LTE base station.

[0103] In some examples, the second configuration information, to be sent to the uplink/downlink modules, may also specify that if the location value of the location tag name of a received packet is equal to 'x', then the uplink/downlink modules should forward the packet to port 'z' of the uplink/downlink module **140**. In this case, the uplink/downlink modules also perform actions typically performed by forwarding module(s).

[0104] Action 2

[0105] In order to make the entry module **170** aware of the first configuration information which keeps track of the location of the mobile device **120**, the management module **147** sends the first configuration information to the entry module **170**. Alternatively or additionally, the management module **147** sends the second configuration information to the downlink module **160** and/or the uplink module **130**.

[0106] Action 2

[0107] may be performed before the mobile device **120** attaches to the system. This may mean that the uplink/downlink modules may be configured with aggregate information that serves multiple mobile devices.

[0108] Generally, action 2 is performed without triggering by mobility of the mobile device **120**.

[0109] Action 3

[0110] As mentioned, the forwarding module **140** may typically not need to be re-configured due to mobility of the mobile device **120**.

[0111] Thus, the management module **147** may configure the forwarding module **140** with third configuration information without triggering by mobility of the mobile device **120**, wherein the third configuration information specifies to which port a packet, having a location value of the set of location values, is to be forwarded.

[0112] Expressed differently, the forwarding module **140** may be configured by the management module **147** with third configuration information, the forwarding module **140** comprising ports towards further forwarding modules and/or the service module **145**, wherein the third configuration information specifies to which port a packet, having the location value, is to be forwarded.

[0113] As an example, the third configuration information, to be sent to the forwarding module **140**, may specify that if the location value of the location tag name of a received packet is equal to 'x', then the forwarding module **140** should forward the packet to port 'z' of the forwarding module **140**.

[0114] In this manner, a mapping from location values to which port a packet is to be forwarded is achieved.

[0115] Action 4

[0116] The entry module **170** may receive, from the management module **147** first configuration information indicating the location tag name and location values associated thereto, wherein each location value is associated to a respective radio network node to which the mobile device **120** is capable of attaching.

[0117] Action 5

[0118] The downlink module **160** receives, from the management module **147**, second configuration information indicating a treatment tag name, and treatment values.

[0119] Action 6

[0120] The uplink module receives, from the management module **147**, second configuration information indicating a treatment tag name, and treatment values.

[0121] Now that the entry module **170**, the forwarding module **140** and the downlink/uplink modules have been configured, the communication system **100** is set up and ready to manage packets travelling between the mobile device **120** and the peer device **180**.

[0122] Action 7

[0123] The forwarding module **140** may receive the third configuration information from the management module **147**, e.g. when the management module **147** configures the forwarding module **140** by sending the third configuration information to the forwarding module **140**.

[0124] Action 8

[0125] Thus, the entry module **170** receives an IP packet from the peer device **180**. The IP packet includes a destination IP address associated with the mobile device **120**. The IP destination address will be used in action 9 to find out to which the radio network node **110** the mobile device **120** is attached.

[0126] Action 9

[0127] This action may be performed in response to action 8 or this action may be performed before action 8.

[0128] The entry module **170** obtains, from the management module **147**, a location value specifying the radio network node **110** associated with the destination IP address.

[0129] In order for the management module **147** to be aware of the location value, it keeps track of the location of mobile device **120**. For example, a radio network node to which the mobile device has attached may report, or send, to the management module **147** that the mobile device **120** with a certain IP address has attached to it.

[0130] The management module **147** may then push the certain IP address and the location value corresponding to the radio network node, to which the mobile device has attached, to the entry module **170**. Alternatively, the management module **147** may send, to the entry module, the certain IP address and the location value upon request from the entry module **170**.

[0131] Action 10

[0132] Subsequent to action 9, the entry module **170** now being aware of the location value associated with the destination IP address of the IP packet received in action 8, the entry module **170** associates the location value with the IP packet. The location value is related to the location tag name, indicating the radio network node **110** that serves the mobile device **120**, thereby obtaining a packet.

[0133] In a first example, the entry module encapsulates the IP packet to form the packet. This may mean that the associating **10** of the location value with the IP packet may comprise generating the packet by encapsulating the IP packet, wherein the packet includes a header comprising the location value and, optionally, the tag name.

[0134] In a second example, the packet may be the IP packet. This means that existing fields of the IP packet are used to store the location value within the IP packet, i.e. without changing a type of the packet. Hence, the associating **10** of the location value with the IP packet may comprise setting the location value as a first option value of the IP packet. As mentioned above, option fields that may include option values are known for IP packets. In this second example, it may be that the destination IP address may be replaced by the location value. Then, the radio network node **110** may re-insert the destination IP address into the IP packet when sending the IP packet to the mobile device. Alternatively, a new IP option is added to the IP header of the packet.

[0135] Action 11

[0136] The entry module **170** sends the packet, via the forwarding module **140**, towards the radio network node **110** as indicated by the location value of the location tag name.

[0137] In some examples, the entry module **170** is directly connected to the downlink module **160** which then will use the location value to find out towards which port thereof it shall forward the packet.

[0138] In some other examples, the entry module **170** may be connected to the downlink module **160** via one or more forwarding modules which then also will use the location value to find out towards which port thereof they shall forward the packet.

In action 12-15, it is described how the downlink module **160** enables efficient service chaining.

[0139] Action 12

[0140] Subsequent to action 11, the downlink module **160** receives, via the entry module **170**, a packet from the peer device **180**.

[0141] Action 13

[0142] The downlink module **160** selects a treatment value out of the treatment values based on information included in the packet, thereby classifying the packet.

[0143] For example, the information may include destination/source IP address of the packet as specified by the above mentioned rule of the second configuration information.

[0144] In some examples, the downlink module **160** may update the location value associated to the packet. In this case, the downlink module **160** may obtain the location value from the management module **147** similarly to how the entry module **170** obtains the location value. An advantage may be that the entry module **170** may update its location values less frequently. See also FIG. **14** below.

[0145] Action 14

[0146] After action 13 has been performed, the downlink module **160** associates the treatment value with the packet, wherein the treatment value is related to the treatment tag name.

[0147] In some embodiments, the packet may be encapsulated. In some examples, this may be a further encapsulation in relation to the encapsulation that may be performed by the entry module **170** in action 10. In other embodiments, a type of the encapsulated packet of action 10 may include specify fields that are filled in by the downlink module **160** in this action.

[0148] Therefore, the associating **14** of the treatment value with the packet may comprise generating a downlink classified packet by encapsulating, either directly or indirectly, the IP packet, wherein the downlink classified packet includes a header comprising the treatment value and, optionally, the treatment tag name. Here a direct encapsulation may mean that the IP packet is reveal when the header of the downlink classified packet is removed. An indirect encapsulation may mean that further headers, possibly added in action 10, may need to be removed before the IP packet is revealed.

[0149] An identity value of the mobile device **120** may be used as a new tag, called an device tag name, or UE tag name. For examples, the identity value helps in identifying the mobile device **120** in case of downlink broadcast/multicast packets, in which case the IP address does not reveal the identity of the mobile device **120**.

[0150] Thus, the associating **14** of the treatment value with the packet may comprise associating an identity value of the mobile device **120** with the identity tag name by encapsulating the packet, wherein the header of the downlink classified packet further includes the identity value. This identity tag may be used by the radio network node **110** in order to find out to which mobile device **120**, attached thereto, to send the packet to.

[0151] In some examples, the associating **10** of the packet does not alter the type of the packet. This may mean that the packet may be an IP packet. Accordingly, the associating **14** of the treatment value with the packet comprises setting the treatment value as a second option value of the IP packet.

[0152] Moreover, in case the packet is an IP packet, the destination IP address of the IP packet may be used to identify the mobile device **120**. In this case, the radio network node **110** uses the destination IP address to find out to which mobile device **120**, attached thereto, to send the packet to.

[0153] When the mobile device moves in the communication system **100**, the path, e.g. via which forwarding modules the packets to the mobile device goes, will most likely change. This means that the packets are now forwarded by different forwarding modules than before the mobile device moved, i.e. there are old forwarding modules in an old path as before movement and there are new forwarding modules in a new path as after the movement. Some forwarding modules may of course remain the same.

[0154] This also means that an old service module that previously handled packets to the mobile device may not be reachable anymore, i.e. by the new forwarding modules that now treats the packets. Therefore, a context of the old service module for that mobile device **120** needs to be moved from the old service module to a new service module. Note that the old and new service module perform the same function. Normally, the old and new service modules are executing on different physical locations, and are thus connected to different forwarding modules. As will be explained further below, the old and new service modules may be different instances of the same functional module.

[0155] Action 15

[0156] The downlink module **160** sends the packet and the associated treatment value, via the forwarding module **140** which performs the treatment of the packet according to the treatment value, towards the radio network node **110**. This may mean that the mobile device **120** does not necessarily receive the treatment value. In some examples, the treatment value may be peeled off by the radio network node **110**, before transmitting the packet to the mobile device **120** over a radio interface.

[0157] Action 16

[0158] The treatment of the packet may comprise invoking, by the forwarding module **140**, at least one service provided by the service module **145**. The forwarding module **140** may of course invoke one or more service modules, each of which provides one or more services. The invoking of service module is however performed by the forwarding module according to the treatment value.

[0159] The treatment of the packet may specify a rule for how the forwarding module **140** performs forwarding. In this case, no service module is invoked. The treatment value may specify priority between different packets by means of the treatment value, e.g. in order to provide Quality of Service QoS-functionality. The priority may be in terms of in which order received packets may be sent or in terms of which ports of the forwarding module to forward to. Here different ports may have different capacity, either inherently or e.g. due to load.

[0160] Action 17

[0161] The Uplink module **130** may receive a mobility event, when the mobile device has moved to a new location, at least one entry module, and possibly also one or more downlink modules, gets updated such that packets for that device get marked with the same tag names, such as the location tag name, but where one or more tags have an updated value, i.e. the location value. The updated value reflects the new location of the mobile device, e.g. reflects the radio network node serving the mobile device at the new location.

[0162] Action 18

[0163] The uplink module **130** receives, via the radio network node **110**, an IP packet from the mobile device **120**.

[0164] The radio network node **110** knows to which uplink module is shall send the uplink IP packets. One way of achieving this is by allowing the uplink module to be

co-located with the radio network node. However, the uplink module and the radio network node may also be separated. The uplink module may therefore, after the mobile device **120** has moved to a radio network node associated thereto receive uplink packets coming from the mobile device **120**.

[0165] For the radio network node, the movement of the mobile device **120**, i.e. mobility of the mobile device may be seen as an event. According to known manner, the radio network node performs various tasks to take care of the mobile device **120** that attempts to attach to it. In contrast thereto, the uplink module merely continues to mark, see action 20, IP packets according to the rules it already has received, see action 6 above.

[0166] Action 19

[0167] The uplink module **130** selects a treatment value out of the treatment values based on information included in the packet, thereby classifying the IP packet. As for the downlink module **160**, the information may include destination/source IP address of the IP packet.

[0168] In some examples, the information may include parameter value marked at the IP packet by the radio network node. The parameter value may specify subscriber status, such as gold, silver, bronze and default, which would lead to different treatment by the forwarding module **140**.

[0169] Action 20

[0170] The uplink module generates an uplink classified packet encapsulating the treatment value and the IP packet, wherein the treatment value is related to the treatment tag name. Notably, the uplink classified packet is different from an IP packet, i.e. the header of the uplink classified packet is different from a known IP packet header. Therefore, the uplink classified packet is a different type of packet compared to a type of the IP packet.

[0171] Moreover, the generating **20** of the uplink classified packet may comprise further encapsulating an identity value of the peer device **180** with an identity tag name for the peer device **180**, into the uplink classified packet.

[0172] Action 21

[0173] The uplink module sends the uplink classified packet, via the forwarding module **140** which performs the treatment of the uplink classified packet according to the treatment value, towards the peer device **180**.

[0174] The treatment of the packet may comprise invoking, by the forwarding module **140**, at least one service provided by the user plane module **145**.

[0175] The treatment of the packet may specify a rule for how the forwarding module **140** performs forwarding.

[0176] Action 22

[0177] Similarly to action 16, but for uplink packets, the forwarding module **140** may treat the packets.

[0178] Now a few more detailed examples will be described. The terms in the subsequent sections correspond to the terms used above as follow:

[0179] mobile device—UE, terminal,

[0180] peer device—peer device, or peer for short,

[0181] radio network node—base station,

[0182] entry module—IAP,

[0183] downlink module—downlink classifier,

[0184] forwarding module—forwarding element,

[0185] service module—User Plane Function,

[0186] uplink module—uplink classifier,

[0187] management module—control node, eMME.

[0188] A more detailed illustration of the proposed architecture for a packet core network for 5G (5^{th} Generation mobile communication systems) is shown in FIG. **7**. FIG. **7** shows the functional view of the proposed architecture.

[0189] A terminal (UE) **701** talks to a peer (not shown) on a network via fixed or radio access and via an operator's data plane. The network is here called as "Internet" **702** but could just as well be a part of the operator's network. A data plane **703** contains one or more User Plane Functions (UPFs) **704-709**. The terms "Data Plane" **703** and "User Plane" are used interchangeably herein. UPFs are functions, or services, chained together. Collectively they implement core network functions, such as networking services. This could be IP-layer functions (e.g. proxy, firewall) or radio-layer functions (e.g. PDCP termination). Function chains, or service chains, may be on different granularity; e.g. a group of UEs, a single UE, or even a single IP flow for a single terminal **701**. A chain may be symmetrical or asymmetrical uplink/downlink, and a UPF may serve uplink or downlink or both.

[0190] A control node, such as an evolved Mobility Management Entity (eMME) **710**, manages the data plane nodes, such as the UPFs **704-709**. It contains a number of control plane functions, including: traditional MME functionality as in existing EPC; a controller for the UPF service chain; and a Location Registry (LR) which is a table, or similar, comprising information on where the UE currently is located, i.e. at which base station it is connected to.

[0191] An IAP (IP Advertisement Point) **711** is the point where static IP routing to/from "Internet" takes the user's traffic. Uplink traffic does not need to pass the IAP **711**. For downlink traffic, IAP **711** queries the LR (not shown) to find out where the terminal **701** is located, i.e. where the packet is to be routed. The frequency of these requests can be optimized in several ways. E.g. the IAP **711** can retrieve all routing rules for a particular UE IP address and cache those. The eMME**710** may also push updated location information to the IAP **711**. Multiple IAPs may advertise the same IP address. This way, there is no single entry point for this terminal's **701** IP address in the packet core network as the PGW (not shown) is for the EPC. In other words, the proposed architecture allows for an anchorless operation.

[0192] FIG. **7** includes, for completeness of the Figure, further elements that are not explicitly involved in the service chain. Thus, in order to not complicate the Figure, reference signs for these elements are omitted. Packets are forwarded between UPFs by Forwarding Elements (FE) **801-805**.

[0193] See FIG. **8**, which illustrates a service chain example for a mobile broadband use case. The Forwarding Elements may perform switching based on the information of one or more fields in the packet header. The switching may be IP routing or Software Defined Networking (SDN) switching. The embodiments herein may preferably be applied to switching in SDNs. An FE forwards each packet to one of its outbound port based on rules it has received from eMME. It drops a packet when there is no rule match for a packet. It does not modify a packet. The forwarding rules in an FE may apply on fields in the packet's header. A header is defined as a sequence of fields preceding a payload, e.g. the payload of a received IP packet. FIG. **8**, mentioned above, shows an example of a network setup for a mobile broadband use case. It has five UPFs: radio protocol handling, a bandwidth limiter, parental control, charging and a firewall. All traffic passes the Forwarding Elements f**1 801**, f**2 802**, f**4 804**, f**5 805** in both uplink and

downlink (solid line). Function f**1 801** may include a set of functions like encryption (over the air link), header compression and radio flow control. Depending on subscription, some users also get their traffic routed through f**3 803** (dashed line).

[0194] FIG. **8** further shows a UE **806**, a base station (BS) **807** and an IAP **808**.

[0195] Note that FIG. **7** only describes the functional view of the architecture. The architecture may be deployed in a distributed way; e.g. a UPF like "RAN protocol handling" may be co-located with the BS on a base station site, and the "firewall" UPF may be running in a centralized national data center. The UPFs may be running on a distributed cloud environment that potentially spans over all the deployment sites.

[0196] The embodiments herein are applicable to the core network architecture presented in FIG. **7**. However, the core architecture of FIG. **7** is further expanded in order to enable a combination of that architecture with service chaining.

[0197] According to embodiments herein one or more tags are added to every individual packet. The tags are used to enable mobility of mobile devices in an efficient manner. A tag is conceptually a name/value pair. E.g. a UE could be identified with a 128-bit tag value with the tag name "UE ID". The name can be encoded explicitly as a field in a packet's header. This approach is e.g. used in the Internet Engineering Task Force (I ETF) Geneva protocol (https://tools.jetf.org/html/draft-gross-geneve-02). Alternatively, the name is not encoded as a field in a packet's header, but it is know that e.g. a certain position in the header holds the value of a certain tag. E.g. the source address in an IPv**4** packet header always starts on bit number **96** and is 32 bits long (https://www.ietf.org/rfc/rfc791. txt). FEs in the chain know how to interpret the tags and forward based on the information in one or more tags.

[0198] Tags are set by a classifier (CL) in both uplink and downlink, i.e. an uplink and downlink classifier, receptively. In the uplink the classifier may be, but does not need to be, co-located with the base station. In the downlink the classifier may be, but does not need to be, co-located with the IAP. There are one or more classifiers in the uplink, and one or more classifiers in the downlink.

[0199] FIG. **9** shows an example with a network setup where a hierarchy of three tags is used. A first tag denotes the UE ID, a second tag denotes the BS ID, a third tag denotes a "default chain" called TagD. This is the normal chain of functions that is used for all packets to/from Internet; i.e. this is the operator's mobile broadband offering. The functions (F**1** through F**5**) **901-905**, **901'-902'**, such as user plane functions, resemble the functions mentioned in the mobile broadband use case example above.

[0200] In this example four base stations **910**, **911**, **912**, **913** are drawn, also referred to as BSa **910**, BSb **911**, BSc **912** and BSd **913**. Each base station **910-913** may serve multiple UEs **920**, **921**, **922**, **923**. An uplink classifier (CL) **930**, **931**, **932**, **933** is close to the base station. There are two instances of F**1 901** and F**2 902**, i.e. a first and a second User Plane Function (forwarding elements are not shown for simplicity—see FIG. **8** for description of UPFs and FEs). The additional instances are F**1' 901'** and F**2' 902'**. For the segment F**3 903**-F**4 904**-F**5 905** there is only a single set of function instances. This setup may be based on network topology. E.g. F**3 903**-F**4 904**-F**5 905** are located in a national data center site, F**1 901** and F**2 902** are located in a local switching center sites, and the base stations **910-913** and uplink classifiers **930-933** are located in base station sites.

[0201] As shown in FIG. **9**, TagD is used for all switching between F**1 901** through F**5 905**. All packets tagged with TagD traverse the same function. But the value of TagD determines through which instances of these functions the packets traverse. Assume now that a UE **920** in FIG. **9** moves from BSa **910** to BSc **912**, then its UPF in F**1 901** would need to be performed by UPF F**1' 901'** (while of course performing the same function). Also switching would, when the UE **920** has moved to BSc **912** from BSa **910**, be performed by the FE (not shown) of F**1' 901'** instead of the FE (not shown) of F**1 901**. According to the embodiments herein, the moving of the UE **920** from BSa **910** to BSc **912** does not imply any reconfiguration of the FE (again not shown) of F**1' 901'**

[0202] FIG. **9** further illustrates a downlink classifier **940** and an IAP **950**.

[0203] FIG. **10** shows how uplink and downlink traffic would be forwarded using a three-level tag hierarchy. Uplink, the CL classifies the packet with a TagD tag. Downlink, the IAP does a lookup in the LR to find out where the UE currently is. The lookup key is the destination IP address of the downlink packet. As a reply, the IAP receives the BS ID of the UE. That is added as tag to the packet. The IAP may even set the UE ID tag. Alternatively, the destination address of the packet serves as UE ID.

[0204] The only missing piece is how the uplink and downlink classifiers know that TagD should be set, and which value. FIG. **11** illustrates how to pre-configure rules for the communication system **100**, e.g. a mobile broadband use case.

[0205] FIG. **11** shows the UE attaching to the network (block **7**). From the UE perspective, the attach procedure is the same as in today's EPC. All rules, both the rules to the classifiers (step **2-3**) and the rules to the FEs (step **4-6**), can be setup before the UE attaches. The uplink classifier close to BSa and BSb could in this example say "all traffic towards Internet should be tagged with TagD=x. Note that this approach enables aggregation of rules. The rules to the classifiers need to be configured only once, regardless how many UEs attach. The same goes for the forwarding rules for the FEs.

[0206] Upon mobility there is no need to re-configure FEs either. FIGS. **12***a* and **12***b* visualizes that there is no need for reconfiguration of FEs. Also here, from a UE perspective the handover procedure is the same as in today's EPC. To achieve service chaining mobility, the IAP obtains a new BS ID for the new location of the UE. That new BS ID can then be set as a tag in downlink packets (step **21**).

[0207] In FIGS. **12***a* and **12***b*, no function relocation, i.e. transfer of context, is needed. Even if this would be needed, e.g. when the UE moves from BSa to BSc, there is still no need to re-configure any FE. This is shown in FIG. **13**. The relocation (step **13**) is described further below.

[0208] The relocation step **13** of FIGS. **13***a* and **13***b* encompasses the copying of user-specific context, also referred to as context of mobile device, from a source instance of a particular function to a target instance of that same function. Context may include user-specific data element like counter, buffers, identifiers, etc.. In FIGS. **13***a*and **13***b* some elements have been omitted (as indicated by dashed lines) to improve legibility of the Figure.

Further Embodiments

[0209] The tag hierarchy above is just one example. Tags could be organized differently. E.g. TagD and TagBS could be combined into a single TagD, where that tag would get a different value for every chain towards a different base station. Such a two-level hierarchy would make the packet header smaller (two tags instead of three tags), but would increase the number of entries of the "TagD" table in the FEs. Exactly which setup of tags to use depends on multiple factors including network topology, size of the network, number of UEs, etc.

[0210] FIG. **14***a* and FIG. **14***b* compare two different hierarchies. FIG. **14***a* is similar to the three-level hierarchy shown above. Functions (f**1**-f**4**) are represented by function instances **1**-**12**. FIG. **14***a* also illustrates an IAP **13** and a classifier **14** as well as a number of base stations (BS) **15**-**18**.

[0211] In FIG. **14***b*, TagD only encompasses the functions (f**3**-f**4**) **1**-**8** of the chain. Each of the functions **1**-**2** has additional instances **3**-**8**. The functions f**1**-f**2** **9**-**12**, including their instances, are covered by another tag, TagDr for region. In these embodiments, an IAP **13** doesn't set a tag for the BS ID, but a tag for the region, i.e. the location value indicates the region. Another downlink classifier **14**, **15**, between f**2** and f**3** sets TagD. Hence, FIG. **14***b* shows a four-level hierarchy.

[0212] The difference in the hierarchies is, apart from the number of tags to carry in each packet, the length and the update rate of the tables in the FEs and the classifiers. E.g., in FIG. **14***a*, the IAP table is updated upon every BS-to-BS handover. But in FIG. **14***b*, the IAP table is only updated upon a BS-to-BS handover between two different regions, e.g. between BS**16** and BS**18**. An handover between BS**16** and BS**17** or between BS**18** and **19** would not require any updating of the IAP table.

[0213] In FIG. **15**, a schematic flowchart of exemplifying methods in the entry module **170** is shown. Again, the same reference numerals as above have been used to denote the same or similar features, in particular the same reference numerals have been used to denote the same or similar actions. Accordingly, the entry module **170** performs a method for managing packets in a communication system **100** based on Software Defined Networking.

[0214] As mentioned, the communication system **100** comprises the entry module **170**, a radio network node **110**, a mobile device **120**, a forwarding module **140**, a service module **145**, a peer device **180** and a management module **147** for managing the forwarding module **140**, the service module **145** and the entry module **170**, wherein a data plane of the communication system **100** comprises the forwarding module **140**, the service module **145** and the entry module **170** and a control plane of the communication system **100** comprises the management module **147**, wherein the mobile device **120** is attached to the radio network node **110**. The entry module comprises an IAP.

[0215] Again, the forwarding module **140** may be configured by the management module **147** with third configuration information, the forwarding module **140** comprising ports towards further forwarding modules and/or the service module **145**, wherein the third configuration information specifies to which port a packet, having the location value, is to be forwarded.

[0216] One or more of the following actions may be performed in any suitable order.

[0217] Action 4

[0218] The entry module **170** may receive, from the management module **147** first configuration information indicating the location tag name and location values associated thereto, wherein each location value is associated to a respective radio network node to which the mobile device **120** is capable of attaching.

[0219] Action 8

[0220] The entry module **170** receives an IP packet from the peer device **180**, wherein the IP packet includes a destination IP address associated with the mobile device **120**;

[0221] Action 9

[0222] The entry module **170** obtains, from the management module **147**, a location value specifying the radio network node **110** associated with the destination IP address;

[0223] Action 10

[0224] The entry module **170** associates the location value with the IP packet, wherein the location value is related to a location tag name, indicating the radio network node **110** that serves the mobile device **120**, thereby obtaining a packet.

[0225] The associating **10** of the location value with the IP packet may comprise generating the packet by encapsulating the IP packet, wherein the packet includes a header comprising the location value and, optionally, the tag name.

[0226] The packet may be the IP packet, wherein the associating **10** of the location value with the IP packet may comprise setting the location value as a first option value of the IP packet.

[0227] Action 11

[0228] The entry module **170** sends the packet, via the forwarding module **140**, towards the radio network node **110** as indicated by the location value of the location tag name.

[0229] The IP packet may be associated with a flow of IP packets from the peer device **180** to the mobile device **120**, wherein at least some other IP packets of the flow are receivable by a further entry module of the communication system **100**.

[0230] The communication system **100** is anchorless in that the entry module **170** is capable of being one of many entry modules for receiving the IP packet, with the destination IP address, into the communication system **100** from any communication network neighboring thereto.

[0231] With reference to FIG. **16**, a schematic block diagram of embodiments of the entry module **170** of FIG. **1** is shown. The entry module **170** is thus configured to manage packets in a communication system **100** based on Software Defined Networking.

[0232] As mentioned, the communication system **100** comprises the entry module **170**, a radio network node **110**, a mobile device **120**, a forwarding module **140**, a service module **145**, a peer device **180** and a management module **147** for managing the forwarding module **140**, the service module **145** and the entry module **170**, wherein a data plane of the communication system **100** comprises the forwarding module **140**, the service module **145** and the entry module **170** and a control plane of the communication system **100** comprises the management module **147**, wherein the mobile device **120** is attached to the radio network node **110**,

[0233] Again, the entry module **170** may comprise an IAP.

[0234] Also again, the IP packet may be associated with a flow of IP packets from the peer device **180** to the mobile

device **120**, wherein at least some other IP packets of the flow are receivable by a further entry module of the communication system **100**.

[0235] The communication system **100** may be anchorless in that the entry module **170** is capable of being one of many entry modules for receiving the IP packet, with the destination IP address, into the communication system **100** from any communication network neighboring thereto.

[0236] The forwarding module **140** may be configured by the management module **147** with third configuration information, the forwarding module **140** comprising ports towards further forwarding modules and/or the service module **145**, wherein the third configuration information specifies to which port a packet, having the location value, is to be forwarded.

[0237] The entry module **170** may comprise a processing module **1601**, such as a means, one or more hardware modules and/or one or more software modules for performing the methods described herein.

[0238] The entry module **170** may further comprise a memory **1602**. The memory may comprise, such as contain or store, a computer program **1603**.

[0239] According to some embodiments herein, the processing module **1601** comprises, e.g. 'is embodied in the form of' or 'realized by', a processing circuit **1604** as an exemplifying hardware module. In these embodiments, the memory **1602** may comprise the computer program **1603**, comprising computer readable code modules executable by the processing circuit **1604**, whereby the entry module **170** is operative to perform the methods of FIG. **6**, and/or FIG. **15**.

[0240] In some other embodiments, the computer readable code modules may cause the entry module **170** to perform the method according to FIG. **6** and/or **15** when the computer readable code modules are executed by the entry module **170**.

[0241] FIG. **16** further illustrates a carrier **1605**, or program carrier, which comprises the computer program **1603** as described directly above.

[0242] In some embodiments, the processing module **1601** comprises an Input/Output module **1606**, which may be exemplified by a receiving module and/or a sending module as described below when applicable.

[0243] In further embodiments, the processing module **1601** may comprise one or more of a receiving module **1610**, an obtaining module **1620**, an associating module **1630**, and a sending module **1640** as exemplifying hardware modules. In other examples, one or more of the aforementioned exemplifying hardware modules may be implemented as one or more software modules.

[0244] Therefore, according to the various embodiments described above, the entry module **170**, the processing module **1601** and/or the receiving module **1610** is operative to, such as configured to, receive an IP packet from the peer device **180**, wherein the IP packet includes a destination IP address associated with the mobile device **120**.

[0245] The entry module **170**, the processing module **1601** and/or the obtaining module **1620** is operative to, such as configured to, obtain, from the management module **147**, a location value specifying the radio network node **110** associated with the destination IP address.

[0246] Moreover, the entry module **170**, the processing module **1601** and/or the associating module **1630** is operative to, such as configured to, associate the location value with the IP packet, wherein the location value is related to a location tag name, indicating the radio network node **110** that serves the mobile device **120**, thereby obtaining a packet.

[0247] The entry module **170**, the processing module **1601** and/or the sending module **1640** is further operative to, such as configured to, send the packet, via the forwarding module **140**, towards the radio network node **110** as indicated by the location value of the location tag name.

[0248] The entry module **170**, the processing module **1601** and/or the associating module **1630** may be operative to, such as configured to, associate the location value with the IP packet by generating the packet by encapsulating the IP packet, wherein the packet includes a header comprising the location value and, optionally, the tag name.

[0249] In some embodiments, the packet is the IP packet. In these embodiments, the entry module **170**, the processing module **1601** and/or the associating module **1630** may be operative to, such as configured to, associate the location value with the IP packet by setting the location value as a first option value of the IP packet.

[0250] The entry module **170**, the processing module **1601** and/or the receiving module **1610**, or a further receiving module, not shown, may be operative to, such as configured to, receive, from the management module **147** first configuration information indicating the location tag name and location values associated thereto, wherein each location value is associated to a respective radio network node to which the mobile device **120** is capable of attaching.

[0251] In FIG. **17**, a schematic flowchart of exemplifying methods in the downlink module **160** is shown. Again, the same reference numerals as above have been used to denote the same or similar features, in particular the same reference numerals have been used to denote the same or similar actions. Accordingly, the downlink module **160** performs a method for managing packets in a communication system **100** based on Software Defined Networking.

[0252] As mentioned, the communication system **100** comprises the downlink module **160**, a radio network node **110**, a mobile device **120**, a forwarding module **140**, a service module **145**, a peer device **180** and a management module **147** for managing the forwarding module **140** and the service module **145**, wherein a data plane of the communication system **100** comprises the downlink module **160**, the forwarding module **140** and the service module **145** and a control plane of the communication system **100** comprises the management module **147**, wherein the mobile device **120** is attached to the radio network node **110**.

[0253] One or more of the following actions may be performed in any suitable order.

[0254] Action 5

[0255] The downlink module **160** receives, from the management module **147**, second configuration information indicating a treatment tag name, and treatment values.

[0256] Action 12

[0257] The downlink module **160** receives, via the entry module **170**, a packet from the peer device **180**.

[0258] Action 13

[0259] The downlink module **160** selects a treatment value out of the treatment values based on information included in the packet, thereby classifying the packet.

[0260] Action 14

[0261] The downlink module **160** associates the treatment value with the packet, wherein the treatment value is related to the treatment tag name.

[0262] The associating of the treatment value with the packet may comprise generating a downlink classified packet by encapsulating the IP packet, wherein the downlink classified packet includes a header comprising the treatment value and, optionally, the treatment tag name.

[0263] The associating **14** of the treatment value with the packet may comprise associating an identity value of the mobile device **120** with a UE tag name by encapsulating the IP packet, wherein the header of the downlink classified packet includes the identity value.

[0264] The packet may be an IP packet, wherein the associating **14** of the treatment value with the packet comprises setting the treatment value as a second option value of the IP packet.

[0265] The packet may be the IP packet, wherein the destination IP address of the IP packet is used to identify the mobile device **120**.

[0266] Action 15

[0267] The downlink module **160** sends the packet and the associated treatment value, via the forwarding module **140** which performs the treatment of the packet according to the treatment value, towards the radio network node **110**.

[0268] The treatment of the packet may comprise invoking, by the forwarding module **140**, at least one service provided by the service module **145**.

[0269] The treatment of the packet may specify a rule for how the forwarding module **140** performs forwarding.

[0270] With reference to FIG. **18**, a schematic block diagram of embodiments of the downlink module **160** of FIG. **1** is shown. The downlink module **160** is thus configured to manage packets in a communication system **100** based on Software Defined Networking.

[0271] As mentioned, the communication system **100** comprises the downlink module **160**, a radio network node **110**, a mobile device **120**, a forwarding module **140**, a service module **145**, a peer device **180** and a management module **147** for managing the forwarding module **140** and the service module **145**, wherein a data plane of the communication system **100** comprises the downlink module **160**, the forwarding module **140** and the service module **145** and a control plane of the communication system **100** comprises the management module **147**, wherein the mobile device **120** is attached to the radio network node **110**.

[0272] The downlink module **160** may comprise a processing module **1801**, such as a means, one or more hardware modules and/or one or more software modules for performing the methods described herein.

[0273] The downlink module **160** may further comprise a memory **1802**. The memory may comprise, such as contain or store, a computer program **1803**.

[0274] According to some embodiments herein, the processing module **1801** comprises, e.g. 'is embodied in the form of' or 'realized by', a processing circuit **1804** as an exemplifying hardware module. In these embodiments, the memory **1802** may comprise the computer program **1803**, comprising computer readable code modules executable by the processing circuit **1804**, whereby the downlink module **160** is operative to perform the methods of FIG. **6** and/or FIG. **17**.

[0275] In some other embodiments, the computer readable code modules may cause the downlink module **160** to perform the method according to FIG. **6** and/or **17** when the computer readable code modules are executed by the downlink module **160**.

[0276] FIG. **18** further illustrates a carrier **1805**, or program carrier, which comprises the computer program **1803** as described directly above.

[0277] In some embodiments, the processing module **1801** comprises an Input/Output module **1806**, which may be exemplified by a receiving module and/or a sending module as described below when applicable.

[0278] In further embodiments, the processing module **1801** may comprise one or more of a receiving module **1810**, a selecting module **1820**, an associating module **1830**, and a sending module **1840** as exemplifying hardware modules. In other examples, one or more of the aforementioned exemplifying hardware modules may be implemented as one or more software modules.

[0279] Therefore, according to the various embodiments described above, the downlink module **160**, the processing module **1801** and/or the receiving module **1810** is operative to, such as configured to, receive, from the management module **147**, second configuration information indicating a treatment tag name, and treatment values, performed by the forwarding module **140**, of the packets, and to receive, via the entry module **170**, a packet from the peer device **180**.

[0280] The downlink module **160**, the processing module **1801** and/or the selecting module **1820** is operative to, such as configured to,select a treatment value out of the treatment values based on information included in the packet, thereby classifying the packet.

[0281] The downlink module **160**, the processing module **1801** and/or the associating module **1810** is further operative to, such as configured to, associate the treatment value with the packet, wherein the treatment value is related to the treatment tag name.

[0282] Moreover, the downlink module **160**, the processing module **1801** and/or the sending module **1840** is operative to, such as configured to, send the packet and the associated treatment value, via the forwarding module **140** which performs the treatment of the downlink classified packet according to the treatment value, towards the radio network node **110**.

[0283] The treatment of the packet may comprise invoking, by the forwarding module **140**, at least one service provided by the user plane module **145**.

[0284] The treatment of the packet may specify a rule for how the forwarding module **140** performs forwarding.

[0285] The downlink module **160**, the processing module **1801** and/or the associating module **1810** may further be operative to, such as configured to, associate the treatment value with the packet by generating a downlink classified packet by encapsulating the IP packet, wherein the downlink classified packet includes a header comprising the treatment value and, optionally, the treatment tag name.

[0286] The downlink module **160**, the processing module **1801** and/or the associating module **1810** may further be operative to, such as configured to, associate the treatment value with the packet by associating an identity value of the mobile device **120** with a UE tag name by encapsulating the IP packet, wherein the header of the downlink classified packet includes the identity value.

[0287] The packet maybe an IP packet, wherein the downlink module **160**, the processing module **1801** and/or the associating module **1810** may further be operative to, such as configured to, associate the treatment value with the packet by setting the treatment value as a second option value of the IP packet.

[0288] The packet may be the IP packet, wherein the destination IP address of the IP packet may be used to identify the mobile device **120**.

[0289] In FIG. **19**, a schematic flowchart of exemplifying methods in the management module **147** is shown. Again, the same reference numerals as above have been used to denote the same or similar features, in particular the same reference numerals have been used to denote the same or similar actions. Accordingly, the management module **147** performs a method for managing configuration information in a communication system **100** based on Software Defined Networking.

[0290] As mentioned, the communication system **100** comprises an entry module **170**, a downlink module **170**, a forwarding module **140**, and an uplink module **130**, wherein a data plane of the communication system **100** comprises the forwarding module **140** and a control plane of the communication system **100** comprises the management module **147**.

[0291] One or more of the following actions may be performed in any suitable order.

[0292] Action 1

[0293] The management module **147** generates first configuration information and/or second configuration information, wherein the first configuration information indicates a location tag name and location values, wherein each location value is associated to a respective radio network node to which the mobile device **120** is capable of attaching, and/or

[0294] the second configuration information indicates a treatment tag name and treatment values and a rule for treatment, performed by the forwarding module **140**, of the packets. The rule of the second configuration information may specify how to select a treatment value based on destination IP address and/or source IP address of a packet.

[0295] Action 2

[0296] The management module **147** sends the first configuration information to the entry module **170** and/or sends the second configuration information to the downlink module **160** and/or the uplink module **130**.

[0297] Action 3

[0298] The management module **147** may configure the forwarding module **140** with third configuration information without triggering by mobility of the mobile device **120**, wherein the third configuration information specifies to which port a packet, having a location value of the set of location values, is to be forwarded.

[0299] With reference to FIG. **20**, a schematic block diagram of embodiments of the management module **147** of FIG. **1** is shown. The management module **147** is thus configured to manage configuration information in a communication system **100** based on Software Defined Networking.

[0300] As mentioned, the communication system **100** comprises an entry module **170**, a downlink module **170**, a forwarding module **140**, and an uplink module **130**, wherein a data plane of the communication system **100** comprises the forwarding module **140** and a control plane of the communication system **100** comprises the management module **147**.

[0301] The management module **147** may comprise a processing module **2001**, such as a means, one or more hardware modules and/or one or more software modules for performing the methods described herein.

[0302] The management module **147** may further comprise a memory **2002**. The memory may comprise, such as contain or store, a computer program **2003**.

[0303] According to some embodiments herein, the processing module **2001** comprises, e.g. 'is embodied in the form of' or 'realized by', a processing circuit **2004** as an exemplifying hardware module. In these embodiments, the memory **2002** may comprise the computer program **2003**, comprising computer readable code modules executable by the processing circuit **2004**, whereby the management module **147** is operative to perform the methods of FIG. **6** and/or FIG. **19**.

[0304] In some other embodiments, the computer readable code modules may cause the management module **147** to perform the method according to FIG. **6** and/or **19** when the computer readable code modules are executed by the management module **147**.

[0305] FIG. **20** further illustrates a carrier **2005**, or program carrier, which comprises the computer program **2003** as described directly above.

[0306] In some embodiments, the processing module **2001** comprises an Input/Output module **2006**, which may be exemplified by a receiving module and/or a sending module as described below when applicable.

[0307] In further embodiments, the processing module **2001** may comprise one or more of a generating module **2010**, a sending module **2020**, and a configuring module **2030** as exemplifying hardware modules. In other examples, one or more of the aforementioned exemplifying hardware modules may be implemented as one or more software modules.

[0308] Therefore, according to the various embodiments described above, the management module **147**, the processing module **2001** and/or the generating module **2010** is operative to, such as configured to, generate first configuration information and/or second configuration information, wherein the first configuration information indicates a location tag name and location values, wherein each location value is associated to a respective radio network node to which the mobile device **120** is capable of attaching, and/or the second configuration information indicates a treatment tag name and treatment values and a rule for treatment, performed by the forwarding module **140**, of the packets.

[0309] The management module **147**, the processing module **2001** and/or the sending module **2020** is operative to, such as configured to, send the first configuration information to the entry module **170** and/or to send the second configuration information to the downlink module **160** and/or the uplink module **130**.

[0310] The rule of the second configuration information may specify how to select a treatment value based on destination IP address and/or source IP address of a packet.

[0311] Moreover, the management module **147**, the processing module **2001** and/or the configuring module **2030** is operative to, such as configured to, configure the forwarding module **140** with third configuration information without triggering by mobility of the mobile device **120**, wherein the

third configuration information specifies to which port a packet, having a location value of the set of location values, is to be forwarded.

[0312] In FIG. **21**, a schematic flowchart of exemplifying methods in the uplink module **130** is shown. Again, the same reference numerals as above have been used to denote the same or similar features, in particular the same reference numerals have been used to denote the same or similar actions. Accordingly, the uplink module **130** performs a method for managing packets in a communication system **100** based on Software Defined Networking.

[0313] As mentioned, the communication system **100** comprises the uplink module **130**, a radio network node **110**, a mobile device **120**, a forwarding module **140**, a service module **145**, a peer device **180** and a management module **147** for managing the forwarding module **140** and the service module **145**, wherein a data plane of the communication system **100** comprises the uplink module **130**, the forwarding module **140** and the service module **145** and a control plane of the communication system **100** comprises the management module **147**, wherein the mobile device **120** is attached to the radio network node **110**.

[0314] One or more of the following actions may be performed in any suitable order.

[0315] Action 6

[0316] The uplink module **130** receives, from the management module **147**, second configuration information indicating a treatment tag name, and treatment values.

[0317] Action 18

[0318] The uplink module **130** receives, via the radio network node **110**, an IP packet from the mobile device **120**.

[0319] Action 19

[0320] The uplink module **130** selects a treatment value out of the treatment values based on information included in the packet, thereby classifying the IP packet.

[0321] Action 20

[0322] The uplink module **130** generates an uplink classified packet encapsulating the treatment value and the IP packet, wherein the treatment value is related to the treatment tag name.

[0323] The generating **20** of the uplink classified packet comprises further encapsulating an identity value of the peer device **180** with an identity tag name into the uplink classified packet.

[0324] Action 21

[0325] The uplink module **130** sends the uplink classified packet, via the forwarding module **140** which performs the treatment of the uplink classified packet according to the treatment value, towards the peer device **180**.

[0326] The treatment of the packet may comprise invoking, by the forwarding module **140**, at least one service provided by the user plane module **145**.

[0327] The treatment of the packet may specify a rule for how the forwarding module **140** performs forwarding.

[0328] With reference to FIG. **22**, a schematic block diagram of embodiments of the uplink module **130** of FIG. **1** is shown. The uplink module **130** is thus configured to manage packets in a communication system **100** based on Software Defined Networking.

[0329] As mentioned, the communication system **100** comprises the uplink module **130**, a radio network node **110**, a mobile device **120**, a forwarding module **140**, a service module **145**, a peer device **180** and a management module **147** for managing the forwarding module **140** and the service module **145**, wherein a data plane of the communication system **100** comprises the uplink module **130**, the forwarding module **140** and the service module **145** and a control plane of the communication system **100** comprises the management module **147**, wherein the mobile device **120** is attached to the radio network node **110**.

[0330] The uplink module **130** may comprise a processing module **2201**, such as a means, one or more hardware modules and/or one or more software modules for performing the methods described herein.

[0331] The uplink module **130** may further comprise a memory **2202**. The memory may comprise, such as contain or store, a computer program **2203**.

[0332] According to some embodiments herein, the processing module **2201** comprises, e.g. 'is embodied in the form' of or 'realized by', a processing circuit **2204** as an exemplifying hardware module. In these embodiments, the memory **2202** may comprise the computer program **2203**, comprising computer readable code modules executable by the processing circuit **2204**, whereby the uplink module **130** is operative to perform the methods of FIG. **6** and/or FIG. **21**.

[0333] In some other embodiments, the computer readable code modules may cause the uplink module **130** to perform the method according to FIG. **6** and/or **21** when the computer readable code modules are executed by the uplink module **130**.

[0334] FIG. **22** further illustrates a carrier **2205**, or program carrier, which comprises the computer program **2203** as described directly above.

[0335] In some embodiments, the processing module **2201** comprises an Input/Output module **2206**, which may be exemplified by a receiving module and/or a sending module as described below when applicable.

[0336] In further embodiments, the processing module **2201** may comprise one or more of a receiving module **2210**, a selecting module **2220**, a generating module **2230**, and a sending module **2240** as exemplifying hardware modules. In other examples, one or more of the aforementioned exemplifying hardware modules may be implemented as one or more software modules.

[0337] Therefore, according to the various embodiments described above, the uplink module **130**, the processing module **2201** and/or the receiving module **2210** is operative to, such as configured to, receive, from the management module **147**, second configuration information indicating a treatment tag name, and treatment values.

[0338] The uplink module **130**, the processing module **2201** and/or the receiving module **2210** is operative to, such as configured to, receive, via the radio network node **110**, an IP packet from the mobile device **120**.

[0339] The uplink module **130**, the processing module **2201** and/or the selecting module **2220** is operative to, such as configured to, select a treatment value out of the treatment values based on information included in the packet, thereby classifying the IP packet.

[0340] The uplink module **130**, the processing module **2201** and/or the generating module **2230** is operative to, such as configured to, generate an uplink classified packet encapsulating the treatment value and the IP packet, wherein the treatment value is related to the treatment tag name.

[0341] The uplink module **130**, the processing module **2201** and/or the sending module **2240** is operative to, such as configured to, send the uplink classified packet, via the

forwarding module **140** which performs the treatment of the uplink classified packet according to the treatment value, towards the peer device **180**.

[0342] The treatment of the packet may comprise invoking, by the forwarding module **140**, at least one service provided by the user plane module **145**.

[0343] The treatment of the packet may specify a rule for how the forwarding module **140** performs forwarding.

[0344] The uplink module **130**, the processing module **2201** and/or the generating module **2230** may be operative to, such as configured to, generate the uplink classified packet by further encapsulating an identity value of the peer device **180** with an identity tag name into the uplink classified packet.

[0345] As used herein, the term "node", or "network node", may refer to one or more physical entities, such as devices, apparatuses, computers, servers or the like. This may mean that embodiments herein may be implemented in one physical entity. Alternatively, the embodiments herein may be implemented in a plurality of physical entities, such as an arrangement comprising said one or more physical entities, i.e. the embodiments may be implemented in a distributed manner.

[0346] As used herein, the term "unit" may refer to one or more functional units, each of which may be implemented as one or more hardware modules and/or one or more software modules in a node. Thus, the term "module" corresponds to the term "unit", since one or more software/hardware modules may implement a "unit". As used herein, the term "program carrier" may refer to one of an electronic signal, an optical signal, a radio signal, and a computer readable medium. In some examples, the program carrier may exclude transitory, propagating signals, such as the electronic, optical and/or radio signal. Thus, in these examples, the carrier may be a non-transitory carrier, such as a non-transitory computer readable medium.

[0347] As used herein, the term "processing module" may include one or more hardware modules, one or more software modules or a combination thereof. Any such module, be it a hardware, software or a combined hardware-software module, may be a determining means, estimating means, capturing means, associating means, comparing means, identification means, selecting means, receiving means, sending means or the like as disclosed herein. As an example, the expression "means" may be a module corresponding to the modules listed above in conjunction with the Figures.

[0348] As used herein, the term "software module" may refer to a software application, a Dynamic Link Library (DLL), a software component, a software object, an object according to Component Object Model (COM), a software component, a software function, a software engine, an executable binary software file or the like.

[0349] As used herein, the term "processing circuit" may refer to a processing unit, a processor, an Application Specific integrated Circuit (ASIC), a Field-Programmable Gate Array (FPGA) or the like. The processing circuit or the like may comprise one or more processor kernels.

[0350] As used herein, the expression "configured to" may mean that a processing circuit is configured to, or adapted to, by means of software configuration and/or hardware configuration, perform one or more of the actions described herein.

[0351] As used herein, the term "memory" may refer to a hard disk, a magnetic storage medium, a portable computer diskette or disc, flash memory, random access memory (RAM) or the like. Furthermore, the term "memory" may refer to an internal register memory of a processor or the like.

[0352] As used herein, the term "computer readable medium" may be a Universal Serial Bus (USB) memory, a DVD-disc, a Blu-ray disc, a software module that is received as a stream of data, a Flash memory, a hard drive, a memory card, such as a MemoryStick, a Multimedia Card (MMC), Secure Digital (SD) card, etc.

[0353] As used herein, the term "computer readable code units" may be text of a computer program, parts of or an entire binary file representing a computer program in a compiled format or anything there between.

[0354] As used herein, the term "radio resource" may refer to a certain coding of a signal and/or a time frame and/or a frequency range in which the signal is transmitted. In some examples, a resource may refer to one or more Physical Resource Blocks (PRB) which is used when transmitting the signal. In more detail, a PRB may be in the form of Orthogonal Frequency Division Multiplexing (OFDM) PHY resource blocks (PRB). The term "physical resource block" is known from 3GPP terminology relating to e.g. Long Term Evolution Systems.

[0355] As used herein, the terms "number" and/or "value" may be any kind of digit, such as binary, real, imaginary or rational number or the like. Moreover, "number" and/or "value" may be one or more characters, such as a letter or a string of letters. "Number" and/or "value" may also be represented by a bit string.

[0356] As used herein, the term "set of" may refer to one or more of something. E.g. a set of devices may refer to one or more devices, a set of parameters may refer to one or more parameters or the like according to the embodiments herein.

[0357] As used herein, the expression "in some embodiments" has been used to indicate that the features of the embodiment described may be combined with any other embodiment disclosed herein.

[0358] Even though embodiments of the various aspects have been described, many different alterations, modifications and the like thereof will become apparent for those skilled in the art. The described embodiments are therefore not intended to limit the scope of the present disclosure.

Annex 1—Source Script for Msc-Generator

[0359] http://mcs-generatorsourceforge.net/

[0360] This can be used in case text of FIGS. **7-10** is difficult to read.

[0361] FIG. **10**:

```
msc=Dinand {
background.color=white;
defstyle pipe [solid=0];
UE [label="\bUE"],
BS [label="\bBS"],
CL [label="\bCL(UL)"],
F2 [label="\bF2"],
F3 [label="\bF3"],
F4 [label="\bF4"],
CLd [label="\bCL(DL)"],
IAP [label="\bIAP"],
```

-continued

```
eMME [label="\beMME"],
peer [label="\bpeer"];
++: User plane traffic example [lgreen] {
    UE->BS: IP packet\n\-src=UE IP@, dst=peer [color=blue];
    BS->CL: IP packet\n\-src=UE IP@, dst=peer [color=blue];
    CL--CL: Classify:\nset TagD=x [lgreen];
    CL->F2-F4: IP packet\-
                TagD=x
                src=UE IP@, dst=peer [color=blue];
    F4->peer: IP packet\-
                src=UE IP@, dst=peer [color=blue];
    peer->IAP: IP packet\n\-src=peer, dst=UE IP@ [color=red];
    ++: If no cached marking rules for UE IP@ [lgreen] {
        IAP->eMME: Request markings\n\-UE IP@;
        eMME->IAP: Reply\n\-UE ID, BS ID;
    };
    IAP->CLd: IP packet\n\-TagUE="UE ID", TagBS="BS
ID"\nsrc=peer, dst=UE IP@ [color=red];
    CLd--CLd: Classify:
                set TagD=x [lgreen];
    CLd->F4-F2: IP packet\n\-TagD=x, TagUE="UE ID", TagBS="BS
ID"\nsrc=peer, dst=UE IP@ [color=red];
    F2->BS: IP packet\-
            TagUE="UE ID", TagBS="BS ID"
            src=peer, dst=UE IP@ [color=red];
    BS->UE: IP packet\n\-src=peer, dst=UE IP@ [color=red];
};
}
```

[0362] FIG. **11**:

```
msc=Dinand {
background.color=white;
defstyle pipe [solid=0];
UE [label="\bUE"],
BS [label="\bBS"],
CL [label="\bCL(UL)"],
FE__F2 [label="\bFE__F2"],
F2 [label="\bF2"],
FE__F3 [label="\bFE__F3"],
F3 [label="\bF3"],
FE__F4 [label="\bFE__F4"],
F4 [label="\bF4"],
CLd [label="\bCL(DL)"],
IAP [label="\bIAP"],
eMME [label="\beMME"],
peer [label="\bpeer"];
++: Pre-attach [lyellow] {
    eMME->CL: Classifier rules\n\-Mark all traffic to Internet with
    TagD=x;
    eMME->CLd: Classifier rules\n\-Mark all traffic from Internet with
    TagD=x;
    eMME->FE__F2: Forwarding rules\-
        TagD=x: UL to FE__F3 via F2, DL to FE__F1 via F2;
    eMME->FE__F3: Forwarding rules\-
        TagP=z: UL to FE__F4 via F3, DL to FE__F2 via F3
        TagD=x: UL to FE__F4, DL to FE__F2;
    eMME->FE__F4: Forwarding rules\-
        TagD=x: UL to Internet via F4, DL to FE__F3 via F4;
};
++: Initial attach [lyellow] {
    UE->BS: Attach Request;
    BS->eMME: Attach Request\n\-UE ID, BS ID;
    eMME--eMME: \-Assign IP@/prefix\nto this UE [color=lyellow];
    eMME--eMME: \-Assign\nservice chain(s)\nfor this UE
    [color=lyellow];
    eMME--eMME: \-Store UE IP@/prefix\nand UE ID\nand BS ID\nin
    LR [color=lyellow];
    eMME->BS-UE: Attach Accept\n\-IP@/prefix;
};
}
```

[0363] FIG. **12**:

```
msc=Dinand {
background.color=white;
defstyle pipe [solid=0];
UE [label="\bUE"],
BSa [label="\bBSa"],
BSb [label="\bBSb"],
FE__F1 [label="\bFE__F1"],
F1[label="\bF1"],
CL [label="\bCL(UL)"],
FE__F2 [label="\bFE__F2"],
F2[label="\bF2"],
CLd [label="\bCL(DL)"],
IAP [label="\bIAP"],
eMME [label="\beMME"],
peer [label="\bpeer"];
block UE<->BSa-eMME: Attach [lyellow];
++: Handover without relocation [lyellow] {
    block UE<->BSa-BSb: Handover from BSa to BSb[lyellow];
    BSa--BSa: \-Re-classify DL packets to TagBS="BSb" [lyellow];
    BSb->eMME: Path Switch Request;
    eMME--eMME: \-Store new BSb ID
                for UE IP@ in LR [lyellow];
    eMME--eMME: \-send update for all
                IAPs that requested
                marking for UE IP@ [lyellow];
    eMME->IAP: Mark all packets for UE IP@
                \-with TagBS="BSb";
    eMME->BSb-UE: Path Switch Request Ack
                -for UE IP@;
    BSb->BSa: Release Resource;
};
++: User plane traffic example, after handover [lgreen] {
    UE->BSb: IP packet\n\-src=UE IP@, dst=peer [color=blue];
    BSb->FE__F1-F1-CL: IP packet\n\-src=UE IP@, dst=peer
    [color=blue];
    CL--CL: \-Classify:
            set TagD=x [lgreen];
    CL->FE__F1 [color=blue];
    FE__F1->FE__F2-F2-peer: IP packet
                \-TagD=x, src=UE IP@, dst=peer [color=blue];
    BSa>>BSb: IP packet (temporary)
                \-TagD=x, TagUE="UE ID", TagBS="BSb"
                src=peer, dst=UE IP@ [color=red];
    peer->IAP: IP packet
            \-src=peer, dst=UE IP@ [color=red];
    ++: If no marking rules for UE IP@[lgreen] {
        IAP->eMME: Request routing rules\n\-UE IP@;
        eMME->IAP: Reply\n\-UE ID, BS ID="BSb";
    };
    IAP->CLd: IP packet
            \-TagUE="UE ID", TagBS="BSb"
            src=peer, dst=UE IP@ [color=red];
    CLd--CLd: \-Classify: setTagD=x [lgreen];
    CLd->F2-FE__F2-F1-FE__F1: IP packet
                \-TagD=x, TagUE="UE ID", TagBS="BSb"
                src=peer, dst=UE IP@ [color=red];
    FE__F1->BSb: IP packet\n\-TagUE="UE ID", TagBS="BSb"
            src=peer, dst=UE IP@ [color=red];
    BSb->UE: IP packet\n\-src=peer, dst=UE IP@ [color=red];
};
}
```

[0364] FIG. **13**:

```
msc=Dinand {
background.color=white;
defstyle pipe [solid=0];
UE [label="\bUE"],
BSa [label="\bBSa"],
FE__F1 [label="\bFE__F1"],
F1[label="\bF1"],
CL [label="\bCL(UL)"],
BSc [label="\bBSc"],
```

-continued

```
FE__F1p [label="\bFE__F1"'],
F1p[label="\bF1"'],
CLp [label="\bCL'(UL)"],
FE__F2 [label="\bFE__F2"],
F2[label="\bF2"],
FE__F2p [label="\bFE__F2"'],
F2p[label="\bF2"'],
FE__F3 [label="\bFE__F3"],
F3[label="\bF3"],
CLd [label="\bCL(DL)"],
IAP [label="\bIAP"],
eMME [label="\beMME"],
peer [label="\bpeer"];
block UE<->BSa-eMME: Attach [lyellow];
++: Handover with relocation [lyellow] {
    block UE<->BSa-BSc: Handover from BSa to BSc[lyellow];
    BSa--BSa: \-Re-classify DL packets to TagBS="BSc" [lyellow];
    BSc->eMME: Path Switch Request;
    eMME--eMME: \-Store new BS ID="BSc"
            for UE IP@ in LR [lyellow];
    eMME--eMME: \-send update for all
            IAPs that requested
            marking for UE IP@ [lyellow];
    eMME->IAP: Mark all packets for UE IP@
            \-with TagD=y TagBS="BSc";
    eMME->BSc-UE: Path Switch Request Ack
                \-for UE IP@;
    BSc->BSa: Release Resource;
        eMME->F1: Relocate to F1';
        eMME->F2: Relocate to F2';
    F1-F2p: Relocate [lyellow];
};
++: User plane traffic example, after handover [lgreen] {
    UE->BSc: IP packet\n\-src=UE IP@, dst=peer [color=blue];
    BSc->FE__F1p-F1p-CLp: IP packet\n\-src=UE IP@, dst=peer
    [color=blue];
    CLp--CLp: \-Classify:
            set TagD=y [lgreen];
    CLp->FE__F1p [color=blue];
    FE__F1p->FE__F2p-F2p-FE__F3-F3-peer: IP packet
        \-TagD=y, src=UE IP@, dst=peer [color=blue];
    BSa>>BSc: IP packet (temporary)
        \-TagD=y, TagUE="UE ID", TagBS="BSc"
        src=peer, dst=UE IP@ [color=red];
    peer->IAP: IP packet
            \-src=peer, dst=UE IP@ [color=red];
    ++: If no marking rules for UE IP@[lgreen] {
        IAP->eMME: Request routing rules\n\-UE IP@;
        eMME->IAP: Reply\n\-UE ID, BS ID="BSc";
    };
    IAP->CLd: IP packet
            \-TagUE="UE ID", TagBS="BSc"
            src=peer, dst=UE IP@ [color=red];
    CLd--CLd: \-Classify: setTagD=y [lgreen];
    CLd->F2p-FE__F2p-F1p-FE__F1p: IP packet
                    \-TagD=y, TagUE="UE ID", TagBS="BSc"
                    src=peer, dst=UE IP@ [color=red];
    FE__F1p->BSc: IP packet\n\-TagUE="UE ID", TagBS="BSc"
            src=peer, dst=UE IP@ [color=red];
    BSc->UE: IP packet\n\-src=peer, dst=UE IP@ [color=red];
};
}
```

1-52. (canceled)

53. A method, performed by an entry module, for managing packets in a communication system based on Software Defined Networking, wherein the communication system comprises the entry module, a radio network node, a mobile device, a forwarding module, a service module, a peer device and a management module for managing the forwarding module, the service module and the entry module, wherein a data plane of the communication system comprises the forwarding module, the service module and the entry module and a control plane of the communication system comprises the management module, wherein the mobile device is attached to the radio network node, wherein the method comprises:

receiving an Internet Protocol (IP) packet from the peer device, wherein the IP packet includes a destination IP address associated with the mobile device;

obtaining, from the management module, a location value specifying the radio network node associated with the destination IP address;

associating the location value with the IP packet, wherein the location value is related to a location tag name, indicating the radio network node that serves the mobile device, thereby obtaining a packet; and

sending the packet, via the forwarding module, towards the radio network node as indicated by the location value of the location tag name.

54. The method of claim **53**, wherein the IP packet is associated with a flow of IP packets from the peer device to the mobile device, wherein at least some other IP packets of the flow are receivable by a further entry module of the communication system.

55. The method of claim **53**, wherein the communication system is anchorless in that the entry module is capable of being one of many entry modules for receiving the IP packet, with the destination IP address, into the communication system from any communication network neighboring thereto.

56. The method of claim **53**, wherein the associating of the location value with the IP packet comprises generating the packet by encapsulating the IP packet, wherein the packet includes a header comprising the location value.

57. The method of claim **53**, wherein the packet is the IP packet, wherein the associating of the location value with the IP packet comprises setting the location value as a first option value of the IP packet.

58. The method of claim **53**, wherein the method comprises:

receiving, from the management module first configuration information indicating the location tag name and location values associated thereto, wherein each location value is associated to a respective radio network node to which the mobile device is capable of attaching.

59. The method of claim **53**, wherein the entry module comprises an Internet Protocol Advertisement Point.

60. A method, performed by a downlink module, for managing packets in a communication system based on Software Defined Networking, wherein the communication system comprises the downlink module, a radio network node, a mobile device, a forwarding module, a service module, a peer device and a management module for managing the forwarding module and the service module, wherein a data plane of the communication system comprises the downlink module, the forwarding module and the service module and a control plane of the communication system comprises the management module, wherein the mobile device is attached to the radio network node, wherein the method comprises:

receiving, from the management module, second configuration information indicating a treatment tag name, and treatment values;

receiving, via the entry module, a packet from the peer device;

selecting a treatment value out of the treatment values based on information included in the packet, thereby classifying the packet;

associating the treatment value with the packet, wherein the treatment value is related to the treatment tag name; and

sending the packet and the associated treatment value, via the forwarding module which performs a treatment of the packet according to the treatment value, towards the radio network node.

61. The method of claim **60**, wherein the associating of the treatment value with the packet comprises generating a downlink classified packet by encapsulating the packet, wherein the downlink classified packet includes a header comprising the treatment value.

62. The method of claim **61**, wherein the associating of the treatment value with the packet comprises associating an identity value of the mobile device with a device tag name by encapsulating the packet, wherein the header of the downlink classified packet includes the identity value.

63. The method of claim **60**, wherein the packet is an IP packet, wherein the associating of the treatment value with the packet comprises setting the treatment value as a second option value of the IP packet.

64. The method of claim **60**, wherein the packet is an IP packet, wherein the destination IP address of the IP packet is used to identify the mobile device.

65. A method, performed by a management module, for managing configuration information in a communication system based on Software Defined Networking, wherein the communication system comprises an entry module, a downlink module, a forwarding module, and an uplink module, wherein a data plane of the communication system comprises the forwarding module and a control plane of the communication system comprises the management module, wherein the method comprises:

generating first configuration information and/or second configuration information,

wherein the first configuration information indicates a location tag name and location values, wherein each location value is associated to a respective radio network node to which the mobile device is capable of attaching, and/or

the second configuration information indicates a treatment tag name and treatment values and a rule for treatment, performed by the forwarding module, of the packets; and

sending the first configuration information to the entry module and/or sending the second configuration information to the downlink module and/or the uplink module.

66. The method of claim **65**, wherein the method comprises:

configuring the forwarding module with third configuration information without triggering by mobility of the mobile device, wherein the third configuration information specifies to which port a packet, having a location value of the set of location values, is to be forwarded.

67. The method of claim **65**, wherein the rule of the second configuration information specifies how to select a treatment value based on destination IP address and/or source IP address of a packet.

68. A method, performed by an uplink module, for managing packets in a communication system based on Software Defined Networking, wherein the communication system comprises the uplink module, a radio network node, a mobile device, a forwarding module, a service module, a peer device and a management module for managing the forwarding module and the service module, wherein a data plane of the communication system comprises the uplink module, the forwarding module and the service module and a control plane of the communication system comprises the management module, wherein the mobile device is attached to the radio network node, wherein the method comprises:

receiving, from the management module, second configuration information indicating a treatment tag name, and treatment values;

receiving, via the radio network node, an IP packet from the mobile device;

selecting a treatment value out of the treatment values based on information included in the packet, thereby classifying the IP packet;

generating an uplink classified packet encapsulating the treatment value and the IP packet, wherein the treatment value is related to the treatment tag name; and

sending the uplink classified packet, via the forwarding module which performs a treatment of the uplink classified packet according to the treatment value, towards the peer device.

69. The method of claim **68**, wherein the generating of the uplink classified packet comprises further encapsulating an identity value of the peer device with an identity tag name into the uplink classified packet.

70. An entry module configured to manage packets in a communication system based on Software Defined Networking, wherein the communication system comprises the entry module, a radio network node, a mobile device, a forwarding module, a service module, a peer device and a management module for managing the forwarding module, the service module and the entry module, wherein a data plane of the communication system comprises the forwarding module, the service module and the entry module and a control plane of the communication system comprises the management module, wherein the mobile device is attached to the radio network node, the entry module comprising:

an input/output circuit configured to send and receive packets;

a processing circuit operatively coupled to the input/output circuit;

and a memory circuit operatively coupled to the processing circuit and storing program instructions for execution by the processing circuit, the program instructions being configured to cause the entry module to:

receive an Internet Protocol (IP) packet from the peer device, wherein the IP packet includes a destination IP address associated with the mobile device;

obtain, from the management module, a location value specifying the radio network node associated with the destination IP address;

associate the location value with the IP packet, wherein the location value is related to a location tag name, indicating the radio network node that serves the mobile device, thereby obtaining a packet; and

send the packet, via the forwarding module, towards the radio network node as indicated by the location value of the location tag name.

71. The entry module of claim **70**, wherein the program instructions are configured to cause the entry module to associate the location value with the IP packet by generating the packet by encapsulating the IP packet, wherein the packet includes a header comprising the location value.

72. The entry module of claim **70**, wherein the packet is the IP packet, wherein the program instructions are configured to cause the entry module to associate the location value with the IP packet by setting the location value as a first option value of the IP packet.

73. The entry module of claim **70**, wherein the entry module comprises an Internet Protocol Advertisement Point.

74. A downlink module configured to manage packets in a communication system based on Software Defined Networking, wherein the communication system comprises the downlink module, a radio network node, a mobile device, a forwarding module, a service module, a peer device and a management module for managing the forwarding module and the service module, wherein a data plane of the communication system comprises the downlink module, the forwarding module and the service module and a control plane of the communication system comprises the management module, wherein the mobile device is attached to the radio network node, the downlink module comprising:

an input/output circuit configured to send and receive packets;

a processing circuit operatively coupled to the input/output circuit;

and a memory circuit operatively coupled to the processing circuit and storing program instructions for execution by the processing circuit, the program instructions being configured to cause the downlink module to:

receive, from the management module, second configuration information indicating a treatment tag name, and treatment values, performed by the forwarding module, of the packets;

receive, via the entry module, a packet from the peer device;

select a treatment value out of the treatment values based on information included in the packet, thereby classifying the packet;

associate the treatment value with the packet, wherein the treatment value is related to the treatment tag name; and

send the packet and the associated treatment value, via the forwarding module which performs a treatment of the downlink classified packet according to the treatment value, towards the radio network node.

75. The downlink module of claim **74**, wherein the program instructions are configured to cause the downlink module to associate the treatment value with the packet by generating a downlink classified packet by encapsulating the IP packet, wherein the downlink classified packet includes a header comprising the treatment value.

76. The downlink module of claim **75**, wherein the program instructions are configured to cause the downlink module to associate the treatment value with the packet by associating an identity value of the mobile device with a device tag name by encapsulating the IP packet, wherein the header of the downlink classified packet includes the identity value.

77. The downlink module of claim **74**, wherein the packet is an IP packet, wherein the program instructions are configured to cause the downlink module to associate the treatment value with the packet by setting the treatment value as a second option value of the IP packet.

78. A management module configured to manage configuration information in a communication system based on Software Defined Networking, wherein the communication system comprises an entry module, a downlink module, a forwarding module, and an uplink module, wherein a data plane of the communication system comprises the forwarding module and a control plane of the communication system comprises the management module, the management module comprising:

an input/output circuit configured to send and receive packets;

a processing circuit operatively coupled to the input/output circuit;

and a memory circuit operatively coupled to the processing circuit and storing program instructions for execution by the processing circuit, the program instructions being configured to cause the management module to:

generate first configuration information and/or second configuration information,

wherein the first configuration information indicates a location tag name and location values, wherein each location value is associated to a respective radio network node to which the mobile device is capable of attaching, and/or

the second configuration information indicates a treatment tag name and treatment values and a rule for treatment, performed by the forwarding module, of the packets; and

send the first configuration information to the entry module and/or sending the second configuration information to the downlink module and/or the uplink module.

79. The management module of claim **78**, wherein the program instructions are configured to cause the management module to:

configure the forwarding module with third configuration information without triggering by mobility of the mobile device, wherein the third configuration information specifies to which port a packet, having a location value of the set of location values, is to be forwarded.

80. The management module of claim **78**, wherein the rule of the second configuration information specifies how to select a treatment value based on destination IP address and/or source IP address of a packet.

81. An uplink module configured for managing packets in a communication system based on Software Defined Networking, wherein the communication system comprises the uplink module, a radio network node, a mobile device, a forwarding module, a service module, a peer device and a management module for managing the forwarding module and the service module, wherein a data plane of the communication system comprises the downlink module, the forwarding module and the service module and a control plane of the communication system comprises the management module, wherein the mobile device is attached to the radio network node, the uplink module comprising:

an input/output circuit configured to send and receive packets;

a processing circuit operatively coupled to the input/output circuit;

and a memory circuit operatively coupled to the processing circuit and storing program instructions for execu-

tion by the processing circuit, the program instructions being configured to cause the uplink module to:

receive, from the management module, second configuration information indicating a treatment tag name, and treatment values;

receive, via the radio network node, an IP packet from the mobile device;

select a treatment value out of the treatment values based on information included in the packet, thereby classifying the IP packet;

generate an uplink classified packet encapsulating the treatment value and the IP packet, wherein the treatment value is related to the treatment tag name; and

send the uplink classified packet, via the forwarding module which performs a treatment of the uplink classified packet according to the treatment value, towards the peer device.

82. The uplink module of claim **81**, wherein the program instructions are configured to cause the uplink module to generate the uplink classified packet by further encapsulating an identity value of the peer device with an identity tag name into the uplink classified packet.

* * * * *